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Reducing Dust Hazard in Rock Drilling

Longest Railroad Lift Bridge on M.K.T.

Revamping a 28-year Old Steel Truss Bridge

Traffic and Its Influence on City Development

Welded Steel Plates Seal Rockfill Dam

Tests Provide New Concrete Column Design Data

Assuming Responsibility for Structural Welding

Time Studies of Concrete Paving Bring Savings

◆

Public Works and President Hoover's Letter

President Hoover's letter to the American Society of Civil Engineers seriously beclouds the issue of business revival through public works construction. A statement by the society's special committee and an editorial appraisal of the President's letter appear in this issue.

50c A YARD FOR A NEW PAVEMENT SURFACE!

Washington St., Albany, Ga.—Originally paved with brick in 1905, repaved in 1931.

WHEN officials of Albany, Ga., decided to resurface the main street of their city, paved with brick in 1905, they considered various materials and costs carefully. The decision was to take up the old brick, remove abandoned street car tracks, repair the base where necessary, and relay the same brick after turning them on the side. ▨ The total cost of resurfacing this pavement, 56 feet wide and 1800 feet in length, was approximately 50c a yard! 34c of this amount went for labor. ▨ Today the brick which have served under heavy traffic for more than 25 years, form a smooth, safe pavement which is good for at least another quarter century of service. ▨ Here is an example of true paving economy. And here is an example of the unfairness of judging paving costs on the basis of original investment only. It is the cost per year of service that really counts. And on this basis, brick is always the most economical. ▨ For economy, and smoothness and durability as well, specify modern brick-surfaced pavements.

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F. E. Schmitt, Editor

Volume 108 New York, May 26, 1932 Number 21

President Hoover Misquotes

MISQUOTATION mars President Hoover's letter of reply to the American Society of Civil Engineers on business revival through resumption of public construction. At the outset, the misaddressing of the letter to the mythical "Richard S. Parker" instead of to Herbert S. Crocker, president of the society, gives the uncomfortable suggestion that Mr. Hoover did not read the society's brief. This feeling is strengthened when one finds that the suggestions of the society are misunderstood and misquoted.

According to the President, the society suggested that "the depression can be broken by a large issue of federal government bonds to finance a new program of huge expansion of public-works construction in addition to the already large programs now provided for in the current budgets." The facts are otherwise. The society's brief, published last week (*ENR* May 19, 1932, p. 732), did not advocate expansion of federal public works; it urged business revival through necessary state, county and municipal construction. It did not advocate a federal bond issue, except as a measure of last resort; it recommended as preferable that credit be made available to states and cities through an agency like the Reconstruction Finance Corporation, which in reality is what the President himself advocates!

THERE are worse things than expanding federal public works, and worse things than issuing government bonds (which was done without trepidation or harmful result during the war). However, the present question is not federal works or federal bonds, but the vastly more important matter of business stagnation in the face of doles and crumbling confidence. This is the issue which the American Society of Civil Engineers sought to lay before the President in its brief.

But quite aside from misquotations of the society's suggestions, a deep misappreciation of their background and purpose pervades Mr. Hoover's letter. The background was the fact that private industry each day shows more clearly its inability to start the country on the upgrade. And the purpose, which lies at the very heart of the society's brief, was to revive business before further charity doles should rob the unemployed of self-respect and initiative. When we must choose between the construction of useful community facilities and the demoralization of a dole, political controversy should not be permitted to becloud the issue.

MANY other contradictions, half-truths or misleading statements appear in the President's letter, but they are overshadowed by the basic misappreciation just indicated. The erroneous charge that the society advocated "public works of remote usefulness" or such as would "impose unbearable burdens upon the taxpayer" can be overlooked. The suggestion that toll bridges and toll tunnels provide an answer to the present problem will find little acceptance. A claim that public buildings and highways are "non-productive works" is in conflict with the fact that the federal government pays millions each year for rentals, and that highways produce a huge excise income. The assertion that loans by the Reconstruction Finance Corporation are made without issuing government bonds is a deceptive half-truth, since everyone knows that Treasury money has supplied most or all of the corporation's funds.

BUT after all, the affirmative content of the President's letter is the essential thing. If we examine this content we find first that he brushes aside the plan of creating employment through public works, except for his unworkable singling out of so-called self-liquidating works, most of which are inevitably speculative. One cryptic paragraph in Mr. Hoover's "program" suggests a more friendly attitude: "The continuation of such public works in aid to unemployment as do not place a strain on the taxpayer and do not necessitate government borrowing." But this definition lacks interpretation.

No other plan for making employment is advanced in the letter except the granting of loans to private industry; but no hint is given as to how industry is to put men to work while it lacks orders because so many of its consumers are unemployed.

In simplest summary it may be said that the President advocates charity and rejects public construction. His message to the country may be expressed as doles for the unemployed and faith in the ability of industry with the aid of public money to provide means of existence for the idle masses before they are reduced to the poorhouse. It is a program of inactivity and little hope.

GENERAL agreement will be accorded one statement in the President's letter: "What you want and what I want is to restore normal employment." It is this end to which the brief of the American Society of Civil Engineers was directed. The waiting policy offered in reply, a policy pursued by the Administration for many months past, has led only to continued decline.

It is therefore vital that we continue to look the facts in the face. Until more potent means of restoring employment appear, public-works construction stands as the best means of revival at our command, and calls for our continued active faith. The whole nation must be impressed with its vital importance. Then, despite politics, it will come to realization.

NOTES OF THE WEEK

Confident of the Future

THE most heartening news of the past week was that telling of approval of a government loan of $27,500,000 to the Pennsylvania Railroad for its improvement program. The Reconstruction Finance Corporation has made other large loans to other railroads, but the Pennsylvania loan is for *new work*. It is to be spent for electrification work between New York and Washington and for continuation of the company's terminal reconstruction at Philadelphia, Newark and Baltimore. These enterprises, it is estimated, will provide employment for 15,000 men. Significant also is the fact that the railroad, despite the falling off in income which recently forced it to pass a dividend, has sufficient confidence in the future to commit itself to this vast expenditure. More of this type of thinking needs to be injected into those who say that the country's service facilities are overbuilt!

A Card to Fresno

WHEN the Fresno Irrigation District recently burned its paid-off bonds of $2½ millions face, it celebrated the first complete repayment of funded debt by any California irrigation district. The performance is notable not only for its rarity but also because it was accomplished during a period of sharp decline in commodity prices. The determination of the irrigators to get out of debt in the face of great difficulties entitles them to congratulations. Some other districts under similar conditions lapsed into a resigned conviction that they could not pay, but Fresno kept on paying. The direct reward of the irrigators is an immediate halving of their water assessments, but beyond this they enjoy the proud satisfaction of having made a record of conscientious recognition of their obligations that will long serve as precept and example in irrigation practice to the benefit of the entire art and its votaries.

Hydrogen Sulphide Hazards

DURING recent months there has been an increasing frequency in the reports of fatalities from hydrogen sulphide gas in the operation of sewerage systems and sewage-treatment plants. The most recent report is that of the asphyxiation of two sanitary engineers while working in a sludge-sampling manhole at the Lima, Ohio, sewage plant. It has been known for a long time that an accumulaton of this gas presents a grave danger to human life, but wide appreciation of the seriousness of the hazard has at times appeared to be lacking. Hydrogen sulphide is plainly evident when present in minute quantities in the atmosphere and its offensive odor is unmistakable, but for this very reason its highly toxic nature is apt to be overlooked. This gas can cause death within three minutes in concentrations far lower than those required by carbon monoxide. Its lethal qualities are of the order possessed by hydrocyanic acid. Moreover, the sense of smell is not an infallible warning of its presence, for its first action is to paralyze the olfactory nerve. Its next is to paralyze the heart. The only safe guide to remember that hydrogen sulphide stinks—and kills.

Leading Articles

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Keeping the Pot Boiling

STRUCTURAL stagnation has rarely been cause for concern; on the contrary, the constant stream of improvements and new developments requiring study and evaluation has always constituted a phenomenon of major proportions. That such advance takes place even when construction activity is at low tide is emphasized by several current developments. In this issue, for example, are three articles emphasizing the varied uses to which welding is being put—a bridge is repaired by welding in Kansas City; a college dormitory is welded in New Haven; and a welded steel plate diaphragm is used on a rockfill dam near Colorado Springs. Also, in this issue, results of the most comprehensive tests of reinforced-concrete columns ever undertaken are outlined, results which may have a marked influence on future design practice. Last week test results were presented on a rivet-bolt, a new fastening device proposed as a substitute for rivets, for which both cost savings and the provision of more efficient structural steel joints are claimed. These and many other changes and developments are serving to keep boiling the pot out of which lasting engineering achievements emerge. They challenge the engineer to keep continuously abreast of the times.

Bolts Have Merits

DEVELOPMENT of a new form of bolt for connecting structural-steel members recalls past discussions of the relative virtues of bolts and rivets, and the extensive proof of practice that bolts give efficient structural service in a considerable range of uses. Many building frames are connected wholly by bolts, and most transmission towers are bolted. It has often been proposed to use bolts for all but the main girder-to-column connections in tier buildings, and in a few cases, we believe, this has been done. Yet a traditional belief in very great superiority of the rivet continues. Doubtless it is based in part on the view that a rivet fills even an irregular hole, but probably fully as much so on the fact that a rivet cannot be removed by accident, nor by malice, without special tools and effort. Against this, the bolt is favored by having no heating and possible injury to undergo, and it may be made of high-strength alloy steel. Also the bolt is capable of being locked against accidental removal. The strength, simplicity and cheapness of bolt connections seem to entitle them to wider use than they have received. Reanalysis of their advantages and shortcomings may prove worth while.

Concrete Flow and Shrinkage

STUDY of the results of the concrete column research that has been carried out at Lehigh University and the University of Illinois increases one's admiration for the ability and acumen of the early reinforced-concrete students, both researchers and analytical theorists. Most of their conclusions are verified by the new tests. But in addition the tests vindicate the common sense of engineers generally who have relied on results from experience when gaps such as those caused by shrinkage and flow phenomena appeared in available theory. Shrinkage and flow effects were held by some to be reason enough to question the advisability of using reinforced-concrete columns; observed increase of steel stresses in columns under load was regarded as ominous. But it was also observed that the columns continued to function satisfactorily, and the engineer thereupon weighed experience data against theoretical questioning and chose the former. As a result of the new tests, however, everyone is on firmer ground. Steel stresses in the columns do increase materially and rapidly under load. But they do not reach the yield point of the steel, and, what is most important, the ultimate strength of the columns is in no way impaired by the unloading of the concrete onto the steel. Concrete columns thus are safe, though some present-design practices for reinforced-concrete columns may require revision.

A Steel-Plated Dam

THE rockfill dam recently completed for the water supply of a mountain resort hotel in Colorado, as described in this issue, represents the first use of a welded steel-plate watertight diaphragm in dam construction. In general steel diaphragms have not often been used; when used they were located as core walls in the body of the dam and commonly were protected by masonry and corrosion-resisting coverings. In the present instance the steel-plate structure backed by masonry forms the surfacing of the water side of the dam. Only one other example, also in Colorado, of a steel-faced rockfill dam is called to mind—the Pikes Peak Power Co. dam, constructed in 1901 and described in *Engineering News* of Jan. 1, 1903. In that structure the steel plating was riveted and calked, as in fact have been all steel-plate diaphragms for dams until the latest example of steel facing for the Broadmoor dam. Welding as applied here is notable only as an extension of the process into a new field; no new welding technique was employed. Structurally the sheeting offers novelty in the simple expansion joint construction. Incidentally the expenditure of $700,000 for the water supply of a single hotel colony is not undeserving of mention as an example of modern living standards.

A Profitable Performance Survey

THE efficiency of the constructor in building roads, on which some notable figures are presented in this and the last preceding issues from records kept by the Pennsylvania highway department, is befogged by the changes in practice which occur even in a short time. This confusing factor was particularly evident in the appraisal last week of the effect of equipment invention on contract prices through a ten-year period. In several instances admitted increases in efficiency due to machine improvement were not reflected in reduced costs because standards of quality of structure and precision of workmanship also had been advanced. The bidding prices over the period of ten years would have presented probably quite a different aspect as the result of more perfect equipment had the quality of construction demanded remained constant. Increased production efficiency was not represented by lower prices, but it produced better construction at no higher prices.

In the records of production management given in this issue a truer picture of improvement is presented, because in the three years covered by the record both equipment and construction standards remained substantially unchanged. The comparison is therefore a direct measure of construction efficiency—the management of mechanical and human production forces. The machines and the structure were the constant, production management was the variable. The results in brief show an improvement during two years from 46 per cent to more than 60 per cent, all as a result of concentrated attention to reduction of production losses.

What is most interesting to observe is that the impulse for this improvement came from the simple process of analyzing the constructor's time losses and output, and then repeatedly telling him the facts. The constant repetition probably counted most. The constructor who was told again and again that he was working only three-quarters of the time, and producing only 60 per cent of the capacity of his plant, could not do otherwise than look into his organization and management. The results are written deep in the performance tables given in this issue. They furnish an example by which public-roads officials generally can profit.

Fighting a Disease

SILICOSIS is one of the most harmful of all occupational diseases. Even such brief exposures as four to twelve months to silica dust have produced serious or even fatal results sixteen to twenty years later. With the growing realization of the true nature of this insidious disease have come demands to make it compensable and to eliminate its cause. Canada has placed it on the compensation list. In this country two states, Massachusetts and Wisconsin, recognize it as compensable, though by law it has not been officially designated as such. New York and New Jersey have considered compensation for silicosis victims, but as yet have taken no definite action. Mines on the Rand in South Africa are forced to care for employees who contract the disease.

Nationwide recognition of silicosis is bound to come. Faced with this situation and, we hope, prompted by humane impulses, construction, quarrying and mining interests are seeking means to eliminate harmful silica dust, especially in drilling operations. Wet drilling has proved ineffective in removing the microscopic dust particles responsible for silicosis. The most efficient equipment for this purpose yet devised is the Kelley system, described in this issue. By collecting practically all the dust and cuttings coming from the drill hole, this system goes far toward reducing the silicosis hazard. The inventor and his associates are to be commended for the progress made; their achievements deserve the attention of the industry.

Removal of drilling dust is a major step in reducing the silicosis hazard, but it is not entirely effective. Tests have shown that enough dust is raised in the mucking process, in handling the tools and equipment, and even in walking about, to constitute a hazard when working with high-silica rock. Since it is apparent that complete protection to the employee will ultimately be demanded, the problem should be solved by the industry itself. Toward this end a good start has been made.

Dust Trap Reduces Hazard of Silicosis in Drilling

Device for exhausting dust from drill holes lessens silica infection of lungs—Speed of drilling increased 10 to 20 per cent—Field tests indicate moderate costs

By Theodore Hatch
Instructor in Sanitary Engineering, Harvard University, Boston, Mass.

Full Realization of the harmful effects of silica dust to the human lungs has come within only a comparatively short time. The first attempts to eliminate silica-dust hazard and resulting silicosis were made in the mines of South Africa. So far no entirely satisfactory methods have been developed in that country. Some experiments in dust elimination were carried out five or six years ago in the New York subway excavation, but no tangible results were obtained. In 1928 George S. Kelley, inventor of the equipment described in the following article, used a new type of dust-collecting apparatus in excavating foundations for the Lincoln Building in New York City. Encouraged by the results, he applied his systems on a wide scale on the heavy rock excavation for the new Metropolitan Life Building. This article describes the results obtained and the equipment used in that installation. Since this article was written a much-improved type of equipment has been installed on the Rockefeller Center project in New Work City. The chief improvement has been in the dust-settling apparatus, this machine now being reduced to a size comparable with a portable air compressor, in contrast to the large tanks and piping equipment used at the Metropolitan Life job. The trap used at the drills has also been improved, now consisting of a double metal cone with the hole for the drill steel in the center. Suitable traps have also been perfected for use with drifter and stoper drills, thus making the dust-collecting device adaptable to all forms of small-steel drilling. —Editor.

Exposure to the dust generated by rock drills constitutes a serious health hazard when the rock contains silica in the form of silicon dioxide or quartz. The inspiration of quartz-bearing dust produces definite pathological changes in the lungs, resulting in the development of areas of fibrous tissue. The disease is known as silicosis. It may be characterized by loss of weight, shortness of breath, chest pains and the like; its early diagnosis requires X-ray pictures of the chest. Silicosis is generally complicated by tuberculosis of a particularly fatal type. On an examination of a group of 208 rock drillers, blasters and excavators in New York City it was found that 117, or 57 per cent, gave evidence of the disease.

The silicosis hazard increases with the quartz content of the dust, with dust concentration and with length of exposure. It appears to be inversely proportional to the size of the dust particles, those under 2 or 3 microns (1 micron = 1/25,000 in.) being the most dangerous. Particles over 10 microns in diameter apparently do little or no damage, since they do not reach the depths of the lungs where the injury occurs.

Prevention of silicosis is through control of the dust or by respirators. The first method is more certain, since it eliminates the hazard at its source. Methods of dust control include the use of liquids for capturing the dust and local exhaust ventilation. Both have been employed to control dust from rock drills, although the use of exhaust hoods in the past has been generally unsatisfactory. Wet drilling is fairly common practice in mines and tunnels and has been of great value in reducing the dust hazard, but water does not give complete protection under many conditions.

In quarries, foundation excavations and other surface work no means of control has been general, because it was felt that the natural wind currents were sufficient to disperse the dust and thus remove the hazard. Investigations made in New York City by Smith and Fehnel, however, demonstrated the existence of a real health hazard and the need for adequate control measures. As a result, the New York department of labor in 1929 appointed a committee to investigate the problem and to assist in the preparation of a regulation for the control of the dust hazard among rock drillers and excavators.

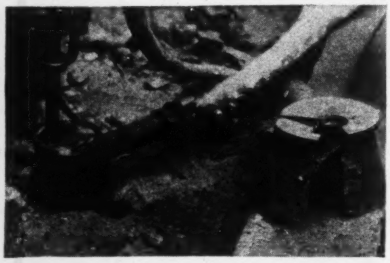


Fig. 1—Trap for use with pneumatic rock drills; at left trap is shown in place, while at the right the trap is open, showing method of inclosing drill steel.

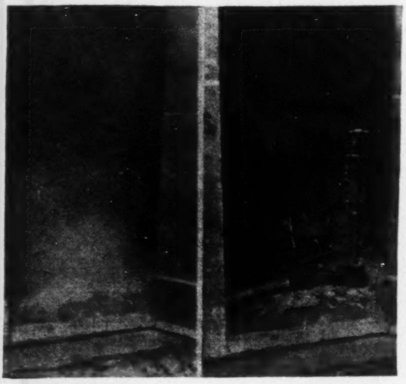


Fig. 2—Comparison of dry drilling with and without trap in operation.

Owing to its inefficiency and practical limitations, wet drilling could not be recommended for general use. The attention of the committee was directed toward a new exhaust hood or trap developed by George S. Kelley, mechanical engineer of the George J. Atwell Foundation Corp., and an investigation of its dust-collecting efficiency was made in a cooperative study conducted by the New York department of labor, the Metropolitan Life Insurance Co., Harvard School of Public Health and the George J. Atwell Foundation Corp. Through the courtesy of the Metropolitan Life Insurance Co. the device was tested under actual field conditions on the excavation for their new building.

Description of trap

The trap is a metal chamber inclosing the drill steel at the rock surface. No attempt is made to secure a mechanical seal with the rock or between the trap and the drill steel. The dust is captured by an air stream as it wells up out of the hole, and it is carried into an exhaust system to which the trap is connected. Any escape of the dust particles through the openings between the uneven rock surface and the trap or around the drill steel is prevented by the air seal produced by the inflowing air.

The trap is illustrated in Fig. 1. It is split to facilitate inserting and removing the drill steel, and the two halves are connected by spring hinges. A simple catch keeps the trap closed during operation. The opening through which the drill steel passes is 1⅜ in., thus permitting free rotation of the steel, which is 1¼ in. or less.

Efficiency of trap

Laboratory studies and investigation in industry have indicated that the lungs are able to resist low concentrations of dust, the maximum permissible amount varying with the quartz content of the rock. For granite dust having a free silica content of about 35 per cent the safe concentration has been set tentatively at 10 to 20 million particles per cubic foot of air. In the South African gold mines, where the free silica content is 80 per cent and more, the safe concentration is said to be 8 to 11 million particles per cubic foot; whereas for the Sydney sandstone, with 85 to 95 per cent free silica, a standard of 5 to 6 million has been advocated.

In scattered rock-drilling operations, dust varying in its SiO_2 content from 0 to 90 per cent or higher may be encountered. On Manhattan Island, for example, the amount of free silica in the surface rock was found by Fehnel to vary from 0.01 to 84.3 per cent. For satisfactory general application any device designed to protect the drill runner from dangerous dust must reduce the dust concentration at the breathing zone below 5 to 6 million particles per cubic foot of air.

Investigation of the trap showed that it reduced the dust concentration below this figure, as indicated by Table I. In most cases these tests were conducted within an inclosure; thus they represent more rigorous conditions than those encountered in open-surface work. The advantages associated with the use of this device are further shown by a comparison of the two views in Fig. 2. A dust concentration as high as 30 million particles per cubic foot is generally invisible to the eye, and hence a visual test of dust-collecting efficiency has little hygienic meaning. The views demonstrate clearly the improved visibility of the operator and the improvement in his general working condition —important factors in determining his productivity. The trap also increased the rate of drilling, as shown in Table II.

TABLE I— DUST CONCENTRATIONS DURING ROCK DRILLING WITH TRAP IN OPERATION

Drill Used	Average Drilling Rate, Ft. Per Hour	Dust Concentration, Million Particles Per Cubic Foot
BCR-430	13	1.84
BCR-430	23	2.6
S-49	16	1.07
S-49	22	1.80
X-59	15	4.35
X-59	11	3.9
3:BCR-430* 4:S-49	..	5.6

*Seven drills set up in a circle 6 ft. in diameter; sample taken in center.

TABLE II — COMPARATIVE RATES OF DRY DRILLING WITH AND WITHOUT TRAP, USING TESTING TRIPOD AND WEIGHTS

(Type S-49 drill and 4-wing steel used throughout)

Weight Applied, Lb.	Feet Drilled Per Hour, Average of Two One-Hour Tests		Per Cent Increase Using Exhaust Hood
	With Trap	Without Trap	
20	17.8	14.7	21.0
40	22.7	20.4	11.0

Application in field

The application of exhaust hoods to scattered and changing points of dust generation requires either a dust collector for each drill or a central collecting plant, with a very flexible system of exhaust piping provided with branch connections to the traps. For many reasons the use of the central system is to be preferred, and on the installation for the new Metropolitan Life Insurance Co. building it was employed.

The exhaust pipe was a 10-in. steel suction main that inclosed the lot at the building line. At intervals along the suction main 6-in. branch inlets were provided, to which were connected flexible hose of varying lengths terminating in suction manifolds, each having connections for ten drills. A 2-in. flexible hose was used between the traps and manifolds, the hose varying in length from 25 to 100 ft. In practice only seven or eight manifolds were in use at one time, and by changing their location as well as the length of the 6- and 2-in. hose every part of the excavated area was easily reached. The exhaust system, which was designed for a capacity of 40 drills, is shown diagrammatically in Fig. 3.

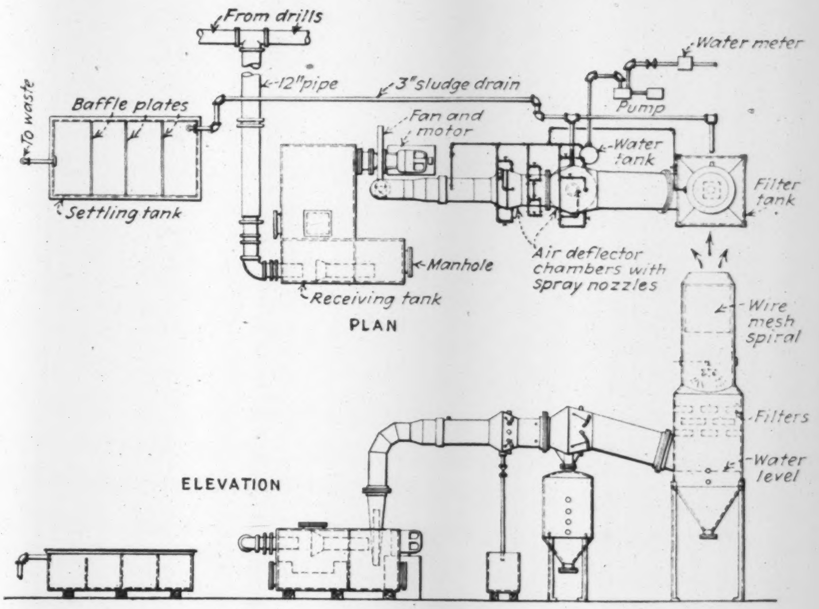


Fig. 3—Diagram plan and elevation of plant for collecting drill dust at Metropolitan Life Building.

The design of the dust-collecting plant in this installation was governed by: (1) efficiency of collection required; (2) nature of material to be handled, such as particle size; (3) amount of material to be taken care of and the dust loading per unit volume of air.

The disposal plant and exhaust fan were located at the street level, with the point of discharge about 8 ft. above the sidewalk and in an open area about 300 ft. on a side. Under these conditions, owing to dilution and dispersion of the dust by wind currents, it was possible to operate with a dust concentration in the discharge air considerably above the hygienic safe limit, without producing a dust hazard at the street level in the neighboring buildings or in the area of excavation.

TABLE III — COST OF OPERATING DUST-CONTROL SYSTEM WITH CAPACITY OF FORTY DRILLS

	Cost Per Week.
Cost of equipmeht, $6,000	
Rental cost and repairs	$100.00
Cost of installation, $1,000	
For six months' use	40.00
Operation (1 operator, 1 field man to 8 drills)	
Six men at $8.25 per day	247.50
Insurance at 10 per cent of payroll	24.75
Power (125 kw.-hr. at 3¾c.)	29.75
Total	$422.00
Cost per drill-day	2.21
Cost per foot drilled (assuming 100 ft. per day per drill)	0.0221
Percentage added cost of dust extraction	
Per foot drilled, assuming cost of drilling at 35c. a foot	6.3
Per yard of stone removed, assuming cost of removal at $5.25 per yard, and 40 yd. per drill day	1.05

The dust produced by rock drills varies from particles ¼ in. or more in diameter down to submicroscopic size, the distribution in size varying somewhat with the nature of the rock, particularly its hardness. The collection of such non-uniform material requires the use of a carefully designed and well-balanced plant and involves at least two steps: preliminary separation of the larger particles in a suitable chamber and the removal of the fine material by filtration. It is essential that the efficiency of removal in the preliminary chamber be made as high as possible in order that the load on the filters remain at a low level.

The trap removes practically all of the dust produced by the drill, and consequently the amount of dust collected is closely represented by the volume of holes drilled. In building excavation an average of 100 ft. a day per drill is commonly obtained. The holes are usually 12 ft. deep and vary from 2 to 1⅜ in. A total volume of about 1.6 cu.ft. of stone will therefore be remove by each drill. For stone weighing 150 lb. per cubic foot, this amounts to 237 lb., and in the form of dust (having 50 per cent voids) will occupy 3.2 cu.ft. In the Metropolitan installation this gave a dust loading in the exhaust system of 0.0082 lb. per cubic foot of air, thereby increasing the density of the mixture to 0.083 lb. per cubic foot (compared with 0.075 for air at 65 deg. F.).

The collecting equipment employed included a preliminary inertial chamber and cloth screen filters. Two compartments were provided in the preliminary sedimentation tank for the removal of large particles.

The secondary stage of filtration was provided by two units, connected in parallel to the discharge pipe from the preliminary tank. The filter area was chosen to give a filtering velocity of 3 ft. a minute, a value that was satisfactory for the efficiency required. The filters were provided with manually operated cleaning devices and storage hoppers for the collected dust. Frequency of cleaning depended upon the number of drills in operation and was determined by the pressure drop across the filters. A water manometer was provided for this purpose, and the resistance was read and recorded every 30 to 45 min. The number of cleaning periods varied from four to ten a day.

The total amount of material collected during an eight-hour working day varied from 2 to 4 tons, with an average of 3 tons for the period of operation from June 1 to Nov. 15. The dust was removed from the primary tank twice each day and once from the filters. It was placed in a storage tank and was thorougly wetted down before being transferred to trucks for removal from the job. Considerable care should be exercised in the cleaning operation, and the dust should be removed and disposed of in a safe manner. As a precautionary measure, the plant operator and assistants should be provided with efficient dust masks to be worn during this operation.

Cost of operation

The complete installation and operating charges against the dust-control system were not available for analysis. An itemized list of representative charges has been prepared, however, and presented in Table III. Further experience with the operation of similar plants may change the figures in some respects, although it is believed that they are fairly correct. According to this analysis, the daily cost was \$2.21 per drill, or \$0.0221 per foot drilled, assuming 100 ft. per drill per day. This amounts to 6.3 per cent of the average drilling cost, and on the basis of cost per yard of stone removed the figure is reduced to 1.05 per cent.

These figures make no allowance for increased rates of drilling or general improvement in working conditions, which in both cases would decrease the net cost of operation. Although further experience will be necessary before definite data can be obtained, the above analysis indicated that the cost of protecting the workers against the health hazard of their occupation is not excessive.

Latest Dust-Collecting Equipment Shown at Rockefeller Center

THE LATEST developments in dust-collecting equipment for three types of drills, jackhammers, drifters and stopers were shown at the Rockefeller Center project in New York City on May 16 by George S. Kelley, inventor of the apparatus, in conjunction with the George T. Atwell Co., contractor on the excavation work, and Theodore Hatch, of the Harvard School of Public Health. The demonstration was staged to show the progress made toward eliminating harmful silica dust on rock drilling, the direct cause of silicosis. Drilling was done with the three types of drills, both with and without the dust collectors in use. In each case the dust cloud created by ordinary dry drilling was entirely eliminated when the collector was in use.

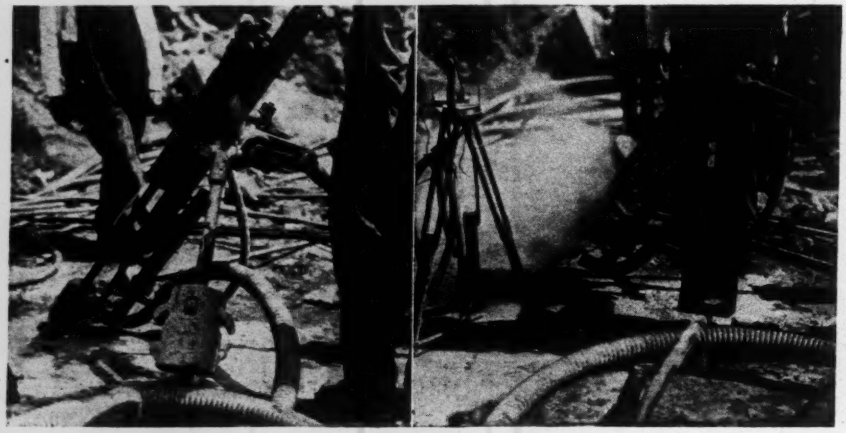


Fig. 1—Demonstration with drifter drill mounted on tripod. The dust trap for drifters consists of a molded rubber cone attached to the drill carriage. View at right shows dust thrown out by drill when collector is not used.

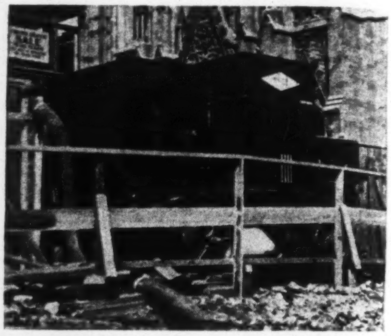


Fig. 2—Entire dust-settling apparatus is now mounted on a portable truck. Contrast this plant with that shown in Fig. 3 of preceding article.

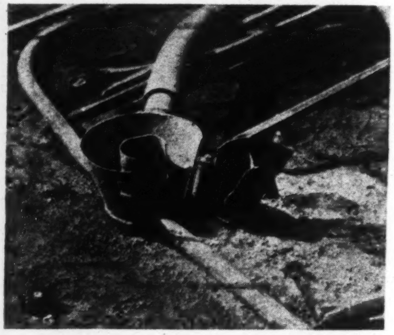


Fig. 3—New type of trap for jackhammers consists of metal double-truncated cone with drill steel passing through center. A segment of the cone is hinged to permit insertion of drill steel. Trap shown here is in upside-down position.

The trap at the drill hole used in connection with the jackhammer drills now consists of a metal double-truncated cone, with the drill-steel hole in the center, as shown in Fig. 3. A quarter segment of the cone is hinged to permit insertion and removal of the steel. Dust is kept from escaping by an inrush of air entering the outer cone. In all the installations, as described in the preceding article, the dust is removed by an air suction leading to a central settling tank.

A molded rubber cone has been developed as a trap for use with drifter drills, shown in Fig. 1. Drill steel is inserted through a slot in the flexible top of the trap, the slot being sealed by a quick-detachable rubber gasket. The trap is mounted on an adjustable pipe arm fastened to the drill carriage and can be placed at the proper distance from the rock face regardless of the position of the drill. Air going into the suction line enters the trap at the rock-face end.

For stoper drills the trap and mounting is somewhat different. A soft rubber trap, conical in shape, is held against the rock face by a separate air piston mounted alongside the feed piston of the drill. Air for the suction line enters the trap from the drill side.

Longest Railway Lift Bridge Is Built by M.K.T. Railroad

Railroad's fourth bridge over the Missouri at Boonville is 408-ft. lift span of silicon steel—Piers replace those built in 1874

HOW increasing loads affect bridge construction is illustrated by the new Missouri River bridge of the Missouri-Kansas-Texas Railroad at Boonville, Mo., this being the fourth structure to carry the railroad at that point. The first bridge was opened in 1874 when the railroad was extended to Denison, Tex., and the present one was opened on Feb. 1, 1932. The first three bridges were in service for 10, 12 and 36 years, respectively. What loading was adopted in the design of the first bridge is not known, but those for the second and third bridges were equivalent, approximately, to Cooper's E-24 and E-30, respectively, while that for the present bridge is Cooper's E-70. Furthermore, the third structure had about 1,500 tons of metal, while the new one weighs nearly 3,000 tons, although some 70 per cent of its material is silicon steel, giving reduced weight for high unit stresses. Its 408-ft. lift span has the distinction of being the longest railway vertical-lift span yet built.

Substructure lasts 60 years

The old substructure, built in 1872 and remaining in use until 1932 (60 years), consisted of a north pier of stone masonry, three iron cylinder piers, three stone piers for the swing span and a stone abutment at the south end. All were sunk to rock, except that the north pier was on piles. Each cylinder pier had twin cylinders filled with rubble stone and connected by a curtain wall below high-water level. The north channel pier was sunk by the pneumatic process, but the others were built in open cofferdams, as the rock rises toward the south.

The substructure built in 1930 for the new bridge consists of five piers and two abutments, all of monolithic concrete. All the piers are founded on rock, and the pneumatic process was used for the four channel piers, with a maximum depth of 59 ft. below low-water level. Both abutments are on piles driven to rock.

The first three bridges

The bridge that was opened to traffic on Jan. 10, 1874, had a 360-ft. swing span; this was flanked on the north by three through spans of 222 ft. 9 in., one of 255 ft. 9 in. and a deck span of 87½ ft., but this deck span was replaced by a fill in 1901. At the south end there was one through span of 255 ft. 9 in. The fixed spans had Post trusses with triple-intersection diagonals. Pairs of 15-in. 150-lb. I-beams formed the floor beams and supported three-ply timber stringers. This structure was built by the American Bridge Co. In ten years this bridge became too light for the traffic (its design loading is unknown), and in 1883-1884 the spans were rebuilt for a loading of two 2-8-0 engines with 88,000 lb. on the drivers, 168,000 lb. total weight of engine and tender and a train load of 2,240 lb. per linear foot. This strengthening was done by Kellogg & Maurice, of Athens, Pa. The truss design was not changed, but some of the members were replaced by heavier sections, and the cast-iron top chord was replaced by built-up wrought-iron sections. It is interesting to note that two of these spans (shortened to 177 ft. and again strengthened) are sill in service on branch lines.

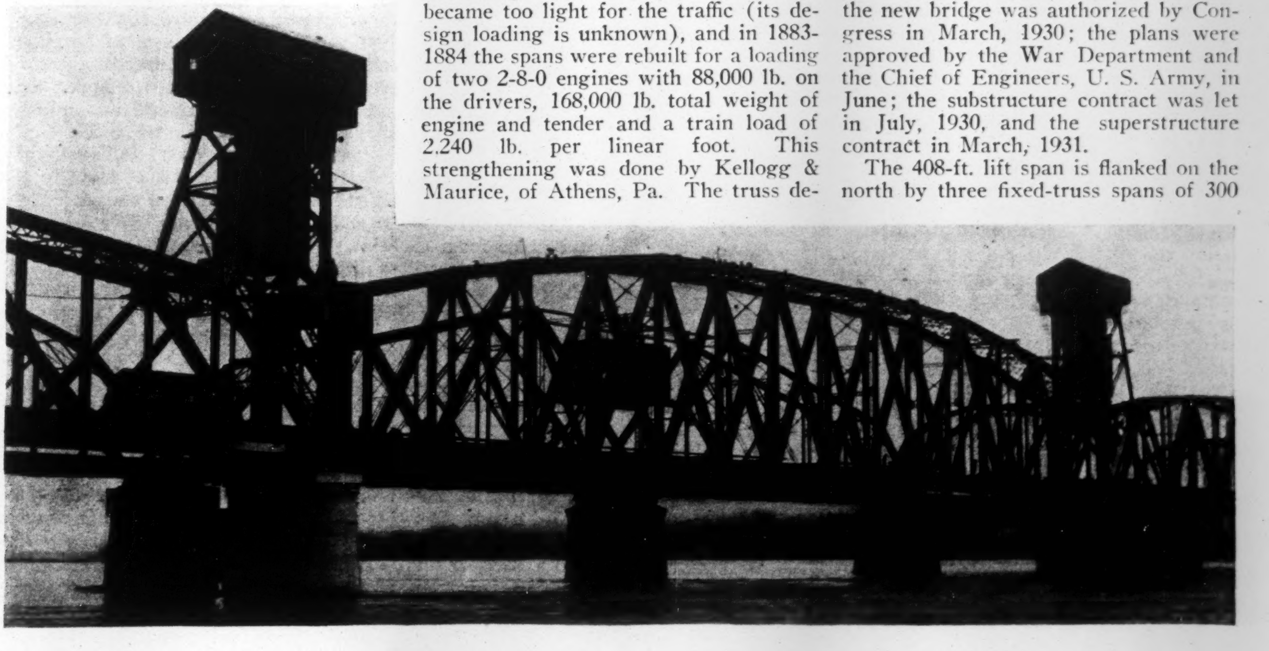
Ten years later it was again necessary to provide greater strength, and in 1894-1896 entirely new spans were built by the A.&P. Roberts Co., of Philadelphia. These were designed for two 2-8-0 locomotives of 208,000 lb., with 112,000 lb. on the drivers followed by a train load of 3,000 lb. per linear foot. Additional strength in the floor system provided for an engine of the 2-8-0 class, with 134,000 lb. on the drivers and a total weight of 229,300 lb. for the engine and tender. This latter is about equivalent to Cooper's E-30 loading. The bridge continued in service until 1932. Some of the counters were strengthened several years ago, and in recent years train speed has been restricted on account of the heavier loading of modern equipment.

New bridge, 1932

Owing to the limited capacity of the old superstructure and disintegration of the stone piers under the heavy loading and the action of water and ice in the river, it became evident in 1929 that complete reconstruction would be necessary. Since a new substructure was required, the logical and economical plan was to locate the new bridge parallel with and downstream from the old structure, the distance adopted being 65 ft. between the center lines. For the channel span the War Department required a clear opening of 400 ft. and clear headroom of 55 ft. at high water. These conditions were met by providing a vertical-lift span. Construction of the new bridge was authorized by Congress in March, 1930; the plans were approved by the War Department and the Chief of Engineers, U. S. Army, in June; the substructure contract was let in July, 1930, and the superstructure contract in March, 1931.

The 408-ft. lift span is flanked on the north by three fixed-truss spans of 300

New 408-ft. lift span of M.K.T. Railroad at Boonville, Mo., parallels old bridge with 360-ft. swing span.



ft., and on the south by a 247-ft. truss followed by a 60-ft. girder span over the Missouri Pacific Railroad. All are through spans and designed for Cooper's E70 loading. The trusses are spaced 20 ft. c. to c., or 17 ft. in the clear, which will permit of laying a gantletted track, with rails 9 in. apart, when the line is double-tracked. At present there is only a single track, laid with 110-lb. rails secured to heavy base plates by bolted clips. The trusses are of the Warren type, with curved upper chords. They have panel lengths of 30 ft. Silicon steel of 24,000-lb. tensile strength is used for all tension members. Plate-girder stringers and floor beams carry an open floor or track deck.

The lift span, the longest of its type in this country, is operated by two 80-hp. motors in each tower, both mounted on the same shaft and geared to the two sheaves 12 ft. 3 in. in diameter, each of which carries sixteen cables, $2\frac{1}{4}$ in. in diameter, attached to the lift span and the counterweights. The weight of the span is about 1,000 tons. The towers are supported partly by the channel piers and partly by the flanking spans.

In raising the bridge the work is performed by one motor of each pair, the other synchronizing the power so as to keep both ends moving at the same speed. Thus if one end should tend to lag behind the other, additional power will be delivered from the synchronizing motor at the higher end. In addition, an automatic leveling device will shut off current and apply the brakes if the difference in elevation of the ends of the bridge reaches a maximum of 6 in. In case of emergency, such as disablement of the synchronizing motor, the operator can control the movement manually. A skew indicator on the control desk shows him at all times the relative elevations of the two ends of the span.

The operating mechanism is interlocked with the signals, current not being available for raising the bridge unless the signals and derails on the approaches are set to stop trains. Similarly, the signals and derails cannot be cleared for passage of trains until the span is lowered and locked. The bridge can be raised for its entire travel of 30 ft. in 70 sec. Current is obtained from a 440-volt line of the Missouri Power & Light Co. Telegraph, telephone and signal cables are carried across the bridge on brackets outside the downstream trusses. Power and light cables, carried in the same way along the upstream trusses, extend from the south end of the bridge to the two towers of the lift span. These cables, estimated to weigh 3.85 lb. per foot, are attached to a messenger wire weighing 0.41 per foot. On the lift span they have sufficient sag to allow for the vertical travel.

Work on the substructure was begun in August and completed in November, 1930. By August, 1931, the railroad had completed the short approach fills, and steel erection was then commenced, that of the lift span being done in the winter, when the falsework would not interfere with navigation.

Engineers and contractors

This new bridge has been designed and built under the direction of Frank Ringer, chief engineer of the Missouri-Kansas-Texas Railroad, with R. M. Stubbs as bridge engineer until his death in April, 1931, and then S. M. Smith, the present bridge engineer; G. L. Staley, assistant bridge engineer, was in direct charge of the work on the ground. The Kansas City Bridge Co. had the contract for the substructure, and the American Bridge Co. fabricated and erected the superstructure. The electric installation was designed by the General Electric Co. in co-operation with the engineers of the American Bridge Co.

Clogged Filtros Plates Rejuvenated With Blow Torch at Milwaukee

ACCIDENTALLY, a workman at the Milwaukee sewage-treatment works turned a blow-torch flame on a clogged filtros plate while he was at the bottom of one of the aeration tanks used in the activated-sludge process. To his surprise the deposit on the top surface of the plate fractured and dusted off, permitting a greater flow of air through the plate.

Top-surface clogging has been relieved heretofore to some extent through the application of a weak hydrochloric acid solution applied liberally and worked into the pores with a scrubbing brush. This method, however, may be said to be comparatively ineffective, in so far as complete restoration of the plate is concerned. Grinding with an emery wheel and sandblasting have been tried to remove the impervious surface from the top of the plate, with comparatively poor results because of the fine particles of gritty substances invariably working their way into the pores of the plate.

After five or six years of operation the pores of the diffuser plates have partly clogged, resulting in an increase of air pressure from 7 to 8 or 9 lb. This is reflected in the power necessary to compress the air. To bring the plates back to normal resistance by utilizing the information accidentally gained, the tanks are emptied of all sewage liquid, the deposits removed and the filtros plates swept off. Then a flame from a blow torch is applied for a few minutes to the surface of each plate, which results in a thin scale (from extreme thinness to $\frac{1}{8}$ in.) being loosened. This scale is swept off, and the surface of the plate is rubbed smooth by a carborundum block applied for a few minutes, after which the plates are swept clean, and the tank is then ready to be placed back into operation. It is most important during the entire process that air be blown continuously through the plates.

After removing the loose deposits in the tank when first drained out, the burning, smoothing and cleaning operation costs 10c. per plate. The process does not injure the filtros plates, the surface of which is left as white as when new. The plates, before being cleaned, are $1\frac{1}{2}$ in. thick. When tried on thinner plates the method failed, as the plates cracked.

Some 35,000 plates have been cleaned during the past year with a saving of approximately 1 lb. in pressure. The plates have shown no indication of clogging up faster than new plates, but it is not yet known how long the cleaning will last. Tentatively it is estimated that the plates might have to be processed every two years, but even at this the cost would be only 5c. per year, or 50c. in five years, against about $2 in five years were the plates to be replaced that often. The officials are of the opinion that plates of a porosity somewhat greater than those installed initially may be expected to last ten years without reconditioning by the burning process.

If it is assumed that during each burning $\frac{1}{8}$ in. is removed, the strength of the plate will be somewhat decreased and the top surface, after the second processing, would be $\frac{1}{4}$ in. lower than the top of the containers, thus affording a recess tending to promote the formation of deposits. Tentatively, only two burnings seem possible to the officials, and then only if the plates are not clogged from below. Clogging from below is largely a matter of cleanliness of air supply. There is evidence of iron oxide coating coming from a flaking off of tiny particles of the cast-iron air pipes. Once a plate has clogged from the bottom side its usefulness ceases.

T. Chalkley Hatton, consulting engineer, Milwaukee sewerage commission, from whom this information has been obtained, states that there appears to be no material damage done to the plate by the one processing so far carried out. The burning-off process was developed and carried out under the direction of James Brower, plant superintendent.

Revamping a 28-Year-Old Steel-Truss Bridge

Damaged by fire, corroded from locomotive gases and worn by long service, old Tenth St. viaduct in Kansas City has its life extended many years by comprehensive yet economical repair program

By James P. Exum
Assistant Engineer, Ash-Howard-Needles & Tammen, Consulting Engineers, Kansas City, Mo.

REPLACEMENT of a wood floor by steel and concrete on spans over railroad tracks, reinforcement of eyebars by welding, provision of new floor beams for old corroded beams and general repair of the old wood floor on the rest of the structure has put the Tenth St. viaduct in Kansas City, Kan., built in 1904, in condition for many more years of useful service. As shown in Fig. 1, the main structure consists of five through-truss spans, of which the north span over the main tracks of the Union Pacific is about 169 ft. long and the others each about 100 ft. long, spanning railroad yards and the tracks of the Chicago, Rock Island and Pacific Railroad. Approaches at either end are deck-girder spans. The viaduct provides a roadway 34 ft. wide with a double-track street railway along its center line and a sidewalk 5 ft. wide outside the east truss. The old sidewalk was of wood plank on timber stringers, and the roadway also was of wood plank supported on wood cross-ties resting on wood stringers, except for one line of steel-beam stringers adjacent to each truss.

A recognized need for repair was made imperative when in June, 1931, the long-truss span and about 25 ft. of the bridge beyond each end of the span were damaged by fire originating in the wooden floor. Damage to the steelwork was comparatively slight, although considerable warping and twisting of some of the members occurred. Prior to this, considerable deterioration from corrosion had occurred in the long north span and the two south truss spans. In fact, the city had prepared plans providing for the replacement of numerous floor members in these two south spans before the fire occurred.

After the fire an investigation by consulting engineers commissioned for the work showed that replacement of the structure was not justified, since it was possible at a reasonable cost to repair it. Three plans were proposed: the first was estimated to cost about $35,000 and contemplated, in general, restoration of the structure to its original condition; plan No. 2 was estimated to cost $102,000 and provided for complete fireproofed floor and sidewalks throughout; and plan No. 3, which was adopted, was estimated to cost $62,000. This plan included provision of fireproofed floors only on the north span and the two south spans, which are most subject to corrosion and fire hazard, and the restoration of the wood floor on the remainder of the structure. The work was carried out in accordance with this plan, excepting only that an asphalt wearing surface was provided on the wood floor at an additional cost of about $3,000. The actual cost of the entire reconstruction was about $1,000 less than was estimated.

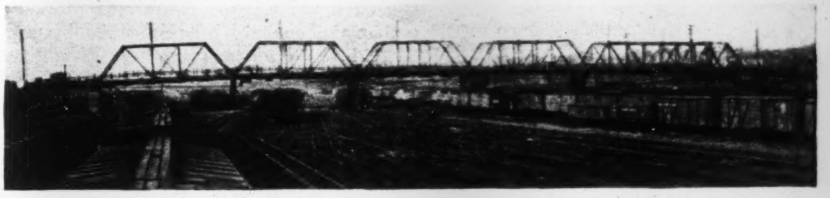


Fig. 1—Tenth St. viaduct, Kansas City, Kan., subjected to locomotive gases since it was built in 1904 and recently damaged by fire, has now been repaired for modern loads and an extended life.

The new fireproof floor on the three spans involved the use of new steel stringers 6½ ft. on centers to replace the wood stringers and new steel cross-beams of 8-in. I's spaced about 3 ft. on centers to carry the deck. The old 5-in. street-car rails were replaced by new 7-in. rails, spanning between the cross-beams. The roadway deck consists of a 6-in. burned-shale aggregate concrete slab with 1½-in. rock asphalt pavement. On each side of each rail there was provided a 5-in. T-beam cut out of a 10-in. I to furnish a separation between the concrete around the rail and the remainder of the slab. The new sidewalk on these spans is of steel plate on 3-in.-Z-bar cross-members with ½-in. asphalt plank surfacing. The sidewalk stringer is placed below the Z's to give an opening to permit smoke and locomotive gases to drift out. Where new fireproof floors were not provided, the old oak plank was removed, any damaged or deteriorated ties and stringers were replaced with good material from the other spans, and the oak plank was relaid. Wood shims had originally been provided on the ties in order to bring the roadway surface up to the top of the street-car rails. Before relaying the plank these shims were removed, making room for an asphalt pavement on the oak plank.

On the old structure provision had been made for expansion of the trusses and girder spans at five points, but none for expansion in the deck. This resulted in a slight buckling of a few bottom-chord eyebars during the fire. In reconstruction the expansion joints were reduced to three, and complete expansion in the roadway deck and in the street-car rails was provided at each of these points. A typical gap-bar detail was provided for the rails. The contract plans provided for a tooth-casting expansion joint for the roadway deck, but at the request of the city, a patented roadway joint, shown in Fig. 4, was substituted. It consists of narrow individual steel castings, skewed to the joint and bolted to heavy steel

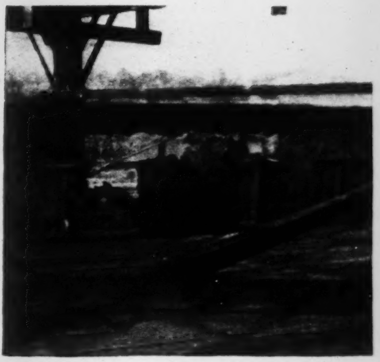


Fig. 2—Floor beam of Tenth St. viaduct after a quarter-century of exposure to locomotive gases.

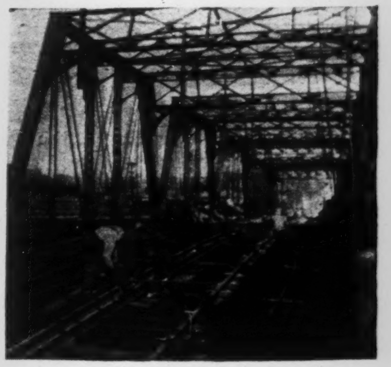


Fig. 3—Steel floor stringers and cross-beams substituted for old wood stringers and cross-ties on three spans. Concrete adjacent to track rails is separated from main-floor slab by a 5-in. T cut from a 10-in. I-beam.

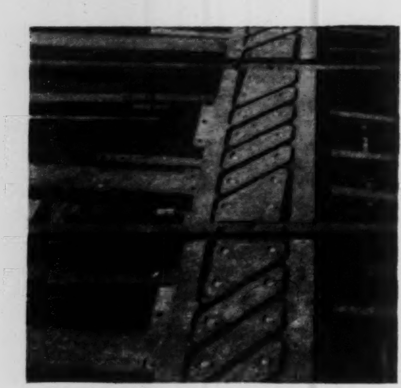


Fig. 4—Patented expansion joints are made up of narrow steel castings skewed to the joint and bolted to angles either side. Slotted holes in the angles permit castings to twist and joint to open or close under temperature changes.

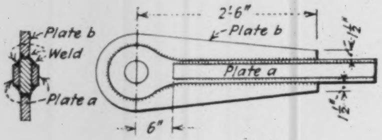


Fig. 5—Corroded eyebars were reinforced by welding plates on either side and, when necessary, by adding a loop of 1-in. plate around the eyebar head by welding.

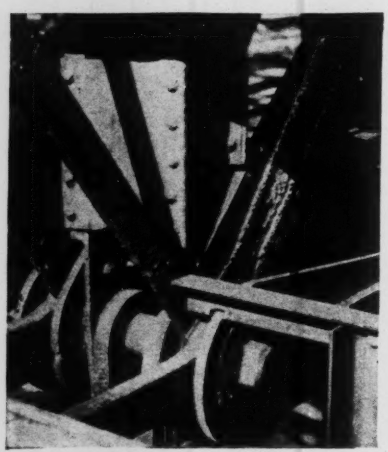


Fig. 6—Typical bottom-chord joint in which both diagonal and chord eyebars have been reinforced by welded plates.

angles on each side. Slotted holes in the angles permit a twisting of the castings under temperature changes. Each bolt has an individual spring under the nut to maintain bearing between casting and angle and to prevent rattling under traffic. All bolts on each side of the joint are connected together by a flat bar underneath the angle supports so as to give unified movement of all gap castings. All truss spans have a skew of about 13 deg.; and this, combined with the presence of the streetcar rails and the fact that the roadway surface was on a grade while the expansion movement was horizontal, made the design of such a joint quite difficult. These problems were, however, worked out satisfactorily, and the joints are working nicely and give a good riding surface.

Repairs to various members were made in some cases by removal and replacement of parts by riveting and elsewhere by welding on reinforcement. The only part of this work of special interest was the reinforcement of some bottom-chord and diagonal eyebars. The contract plans had provided for replacement of certain bottom-chord eyebars and their pins; upon removal of deck and sandblasting and cleaning of the trusses, additional bars were found sufficiently corroded to warrant replacement or reinforcement. These eyebars had been reduced from their original section in some cases as much as 40 per cent, and the eyebar heads were, in instances, also considerably reduced in section. When cleaning of the steel disclosed that none of the pins would need replacing, the contractor proposed that the eyebars be reinforced by arc-welding. This method had the advantage of speeding up construction and would assure better distribution of stresses between the bars of a chord, since it would have been difficult to manufacture a new bar of exactly the correct length without replacing all bars of each weakened member.

The main body of each weakened eyebar (originally 4 in. deep) was reinforced by a $2\frac{1}{2}$-in. bar, of required thickness, on each side of the eyebar and extending the required distance along its longitudinal axis. The $2\frac{1}{2}$-in. bars were firmly clamped in place and tack-welded, after which they were welded continuously to the eyebar with a $\frac{1}{2}$-in. weld for 2 ft. at each end and a $\frac{5}{16}$-in. weld for the remaining portion.

Weakened eyebar heads were reinforced with loops cut from 1-in. plate to templets made in the field and fitted around the heads. The shape and assembly of the loops is shown in Fig. 5. Where packing of the eyebars permitted, the loop was continuous around the head of the eyebar and was assembled by passing the throat of the loop over the pin until the loop was in position at the side of and parallel to the eyebar. It was then moved sidewise into correct position. Where packing of the eyebars did not permit the use of continuous loops, they were split back of the pin, and the two halves were welded together after assembly.

The reinforcement was placed and welded after the old floor had been removed from the spans and before the new floor was constructed. Therefore, at the time of reinforcement the eyebars were carrying a very small percentage of their final stress. In the finished state the eyebar is stressed slightly higher than its reinforcement, but the difference is small. The reinforcement was designed to keep the stress in the original eyebar within the allowable limit.

C. E. Peterson is city engineer of Kansas City, Kan. Plans for the reconstruction were prepared and construction was supervised by Ash-Howard-Needles & Tammen, consulting engineers. The Kansas City Structural Steel Co. was the contractor. The writer served as resident engineer during construction.

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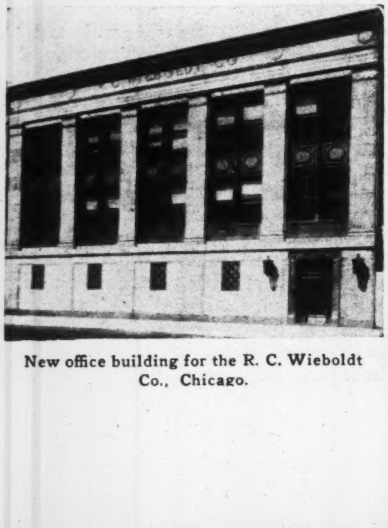
Contractor's Office Building in Chicago Provides Ample Facilities

TO PROVIDE ample facilities for the office work in connection with its general contracting business, the R. C. Wieboldt Co., Chicago, Ill., has erected a three-story office building of special design, shown in the accompanying illustration. This building, of steel and reinforced-concrete construction, has 100-ft. frontage on Jackson Boulevard. General offices and garage space occupy the first floor, with parking space in the rear. On the second floor are the accounting, purchasing and estimating departments, together with a large room for the use of subcontractors. On the third floor are the executive offices and engineering and subcontract departments. Mechanical equipment includes an automatic vacuum-heating system with oil burners and temperature control, supply and exhaust ventilation, electrically refrigerated drinking-water units and a lighting system with specially designed units over the tables in the engineering and estimating departments. The street front is of limestone, with granite base and green mottled terra-cotta spandrels. This company's extensive storage yard and repair shop were described in *Engineering News-Record*, July 14, 1927, p. 62.



New office building for the R. C. Wieboldt Co., Chicago.

Traffic Requirements Determine One Trend in City Development

Modernized traffic facilities bypass through traffic, coordinate mass transport with superhighways, develop radials, utilize alleys for trucks and provide pedestrian concourses and self-contained blocks

By D. Grant Mickle

Former Albert Russel Erskine Fellow in Street Traffic Research, Sheldon Traveling Fellow, Harvard University

From Studies in many cities the author concludes that mass transportation retains its controlling importance, but that street traffic requires greatly enlarged facilities. Separation of through from local traffic, provision of storage for cars, alley loading of trucks and subsurface pedestrian walks are elements of these facilities. Rapid-transit subways should include pedestrian levels between train level and street.

—Editor.

STUDIES in fifteen of the country's largest cities indicate certain definite trends of development to meet traffic requirements. The large city is absolutely dependent upon transportation for its growth and unity. Without adequate and rapid means of transport every city would be a group of independent business, industrial and residence centers, and the cost of conducting business would be increased thereby. Trends disclosed by the studies include: (1) high-speed bypass routes for through traffic; (2) superhighways to feed outer rapid-transit terminals; (3) radials to carry the city traffic to a marginal elevated roadway around the business district; (4) adaptation of the streets in the central area for purely local traffic; (5) alleys for trucking operations; (6) subsurface concourses for pedestrian movement; and (7) large-scale development of self-contained blocks incorporating sufficient parking space for their needs when "no parking" is enforced in the congested district All of these will be seen as common-place developments in the future city designed to meet modern traffic requirements.

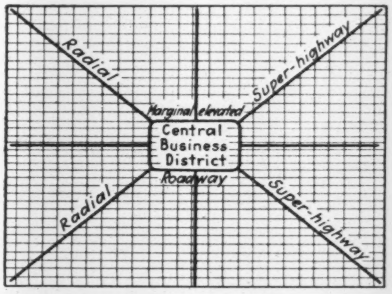
Transportation dominates

When our cities grew to such a size that walking or coach riding became impracticable, certain forms of mass transportation facilities were developed, with elevated and subway rapid-transit systems as the final result. With the increased popularity of the motor car it was soon discovered that streets designed for horse-drawn vehicles and trolley cars were inadequate for large numbers of machines capable of high speeds. Congestion brought decentralization of certain businesses.

Desirable or not as decentralization may be, it is certain that a few enterprises will always seeks to remain intact in one central area. Those requiring personal interoffice communication, those requiring competition for a livelihood, those requiring large numbers of customers, all will hold to the central congested areas. Transportation must then be made available in all its forms for the employees in this central area and for the large masses of people who want to do business there.

It is fortunate that the majority of people who visit the central business district prefer to board a train or street car and read their papers on the way to their destination rather than to worry about driving and parking their own automobiles. It would be utterly impossible to build enough streets leading to the heart of the city to accommodate all the vehicles that would be required to carry those people now carried in mass transportation units. The trend, then, is not toward a discard of mass transportation but rather toward an increase in its use for the majority of people. In this discussion we will consider mainly the trend of development of the facilities for the use of that large number of people who either prefer or are compelled from the nature of their business to drive into the business district.

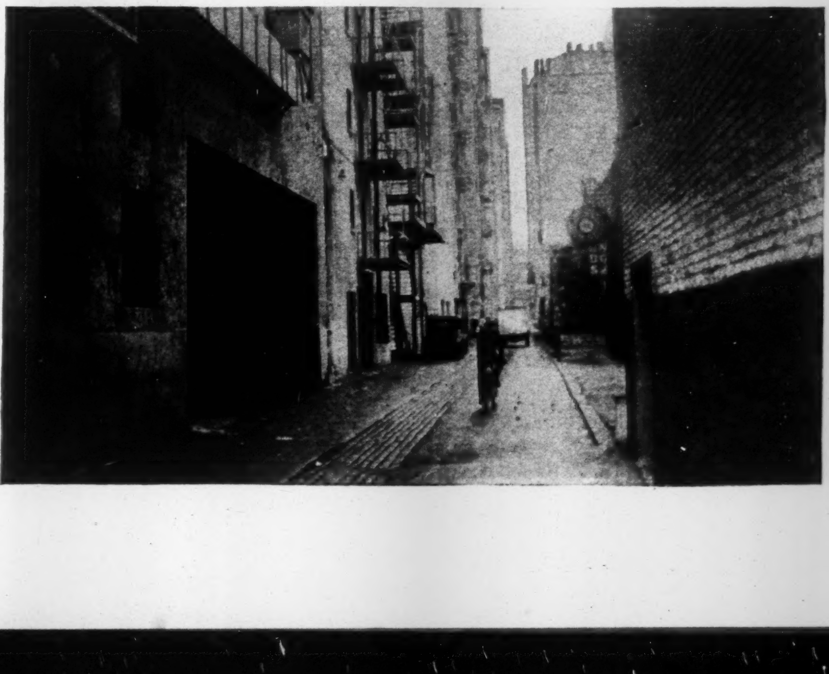
Fig. 1—Idealized radial superhighway system, with central elevated loop street around business district superimposed on rectangular street.



Large fine highways have been built leading to nearly all large cities from every direction, but as they pass the city limits they usually dwindle down to the ordinary narrow city street. In a number of our largest cities steps are being taken to handle these large inflows of traffic more adequately.

High-Speed Bypasses — When completed, the West Side elevated highway in New York will carry the Holland Tunnel traffic by an uninterrupted route to Riverside Drive and thence into the Westchester County parkway system. Thus will through traffic be able to pass rapidly along Manhattan Island without the usual congestion and delay. Chicago is also developing a fine superhighway that will skirt the edge of the Loop and carry through traffic from the south of the city along the lakefront and into the highway systems north of Chicago. In addition, we find in Chicago a development to take care of traffic wishing to enter the Loop district. Wacker Drive, a double-level thoroughfare along the southern bank of the Chicago River, carries traffic leaving Michigan Ave. and the Outer Drive around the southern extremity of the Loop, so that traffic wishing to reach the west or south side of the Loop is not compelled to drive through its entire length or breadth. Detroit is

Fig. 2—Typical Los Angeles alley with loading docks set into buildings.



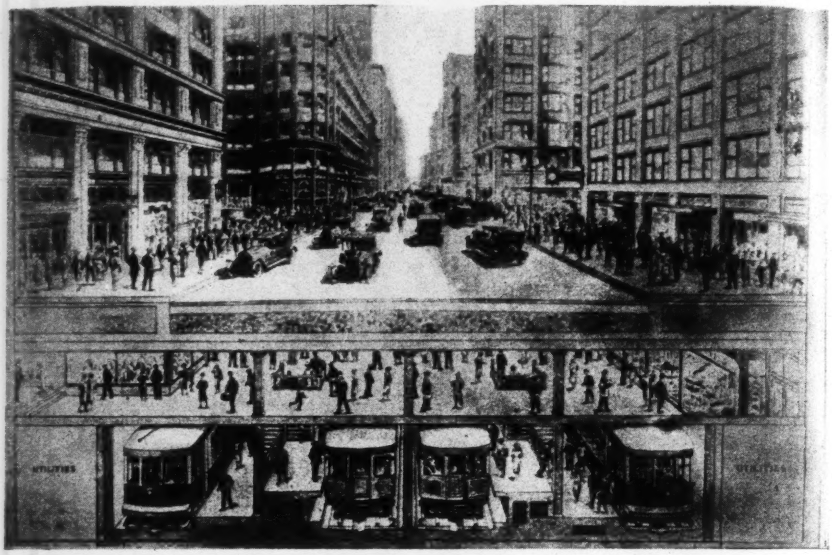


Fig. 3—The proposed Chicago subway has pedestrian concourse in the central business district.

rapidly acquiring a system of 204- and 120-ft. superhighways that will lead directly into the heart of the city. Boston and Los Angeles are widening old streets and opening new ones to relieve the congested conditions near the business district. St. Louis is considering an elevated roadway along the riverfront. And San Francisco has her Embarcadero plan for relieving traffic along the edge of her congested area. Thus we see not only a trend toward fast superhighways to carry traffic to the city or around the congested district but also a trend toward marginal roadways skirting the very edge of the central area.

Vehicle storage necessary

No Parking—In parking ordinances a definite trend is also noticed. No longer do officials think it necessary to allow "first come" to occupy curb space indefinitely. Many cities will not allow parking anywhere within the business district during the morning and evening rush hours and for only a limited time during the intervening hours. In Chicago, parking in the Loop district has been prohibited entirely for several years. Parking garages and open lots have grown in number, but the success of the garage has often been limited by improper location and excessive size.

Self-Contained Buildings—Building development may also be said to display a trend toward meeting modern traffic requirements. Enterprises such as the North Station in Boston, the Grant Building in Pittsburgh, Carew Tower in Cincinnati and the terminal development in Cleveland are examples of so-called self-contained buildings. In the Cleveland Terminal are contained a railroad station, rapid-transit terminal, hotel, office building, bank, parking garage, department store and all the usual stores and shops. It is possible for a man employed in this building to drive his car into the parking garage in the morning and not leave the building until he is ready to drive out that evening. Radio City, the new development in New York, is still another example of a concentrated business area.

The future cities

With these trends as a basis, let us look into the future and try to picture a city designed to meet its traffic requirements. It will be fairly safe to assume that the large masses of people will be carried by some form of rapid transit, preferably subways. A bypass route for fast through traffic will carry motorists past the city without delay. Two present-day examples of such cutoffs are the depressed roadway skirting the business district of Jersey City, N. J., and the elevated roadway being constructed across "the meadows" just outside Newark, N. J.

For the benefit of those commuters and shoppers who dislike riding on suburban trains but who do not care to drive their own cars into the heart of the city, conveniently located rapid-transit terminals at the outskirts of the business area will be equipped with parking facilities so that these people may drive from their suburban homes, park their cars and ride to the business district on the rapid-transit train.

There will always be need for personal transportation into the business area. A system of high-speed safe superhighways that will cut the city into segments will connect with an elevated marginal roadway circumscribing the congested district. No streets will cross these superhighways at grade, and access to them will be at frequent protected entrance points. The local streets, reserved for purely local movement, will be controlled by a flexible, progressive coordinated signal system which will have automatic time settings for different days and various hours of the day. Philadelphia and Pittsburgh are at present using systems that can be regulated to meet conditions as they actually exist and as they arise. Parking will not be permitted at any time on any of the streets within the business district. Buses, loading from indentations at the mid-block, will be the local mass transportation facility.

Moderately sized parking garages, conveniently located throughout the district, will serve the ordinary stores and shops. Large department stores, office buildings and theaters will contain their own parking facilities and may offer them as part of their service just as they provide elevators, rest rooms and lobbies.

The development of blocks in complete units will effect savings in construction cost and operating expense and will greatly improve the appearance of the business district. Blocks containing in one development office space, department store and small shops would support a parking garage within their area during the daytime. At night a theater in the same development would be benefited by the garage facilities.

Alleys for Trucks — Thus far we have not considered the commercial vehicle. Trucks loading or unloading at the curb are a grave hindrance to traffic movement and an annoyance to pedestrians, who must dodge the workmen as they carry their loads across the sidewalk. The city in the future will no doubt be made up of blocks containing alleys of sufficient width to accommodate trucking movements. Each store will be required to ship or receive all goods by means of loading docks opening on the alley.

Subsurface Concourse—And what of the pedestrian? If traffic in the business district is to be speeded up, the pedestrian will have even less chance than he now has to cross the street. Pedestrian tunnels at busy intersections have been tried in Los Angeles, St. Louis and other cities, but they are not at all popular. If our city is to have a rapid-transit subway system, why not a complete pedestrian subsurface concourse between the subway and the street level? Such a concourse is now in use in Broad St., Philadelphia, and similar underground passageways are suggested in the subway plans for St. Louis, Chicago and Detroit. Pedestrians would be free to move with no fear of crossing busy streets. The entire business district could be traversed without being compelled to wait for traffic; protection from sun, rain or snow would be afforded, and more sidewalk space would be available. The only use of the surface sidewalks would be for the purpose of reaching a concourse entrance after leaving a bus, street car or automobile. Buildings would have entrances on the concourse as well as on the surface level. Stores would have two sets of display windows instead of one.

Steel Plates with Welded Joints Seal Rockfill Dam

Initial use of welding in constructing steel face for rockfill dam proves successful in developing a water supply for mountain-resort hotel colony in Colorado

By H. I. Reid

Consulting Engineer, Colorado Springs, Colo.

TWO EXTENSIONS of the water-supply system have been required since 1917 to meet the increasing demands of the Broadmoor Hotel properties near Colorado Springs, Colo. The first supply from springs and tunnel development on the eastern slope of Cheyenne Mountain, about 3 miles from the hotel, was completed in 1917. In 1926 the need for a larger supply was met by constructing a 10-mile pipe line tapping the surface flow of a stream on the western slope of the Pikes Peak range. Unreliability of the surface flow, however, made a new development necessary, and in 1929-30 studies were begun for a storage development on the same stream—East Beaver Creek in Teller County. A suitable location for a dam was found only at a point that required a new pipe line for most of the distance to Broadmoor, and this pipe line (12⅜ miles long) is a part of the new development. The outstanding structure is the dam, the construction of which is the subject of this article.

—EDITOR.

AN UNUSUAL application of welding was made in constructing the steel-plate facing for the rockfill dam for the new water supply for the Broadmoor Hotel, which is about 5 miles from Colorado Springs, Colo. All joints and all assembling bolt heads in the steel plating were welded to insure an absolutely tight and strong face diaphragm.

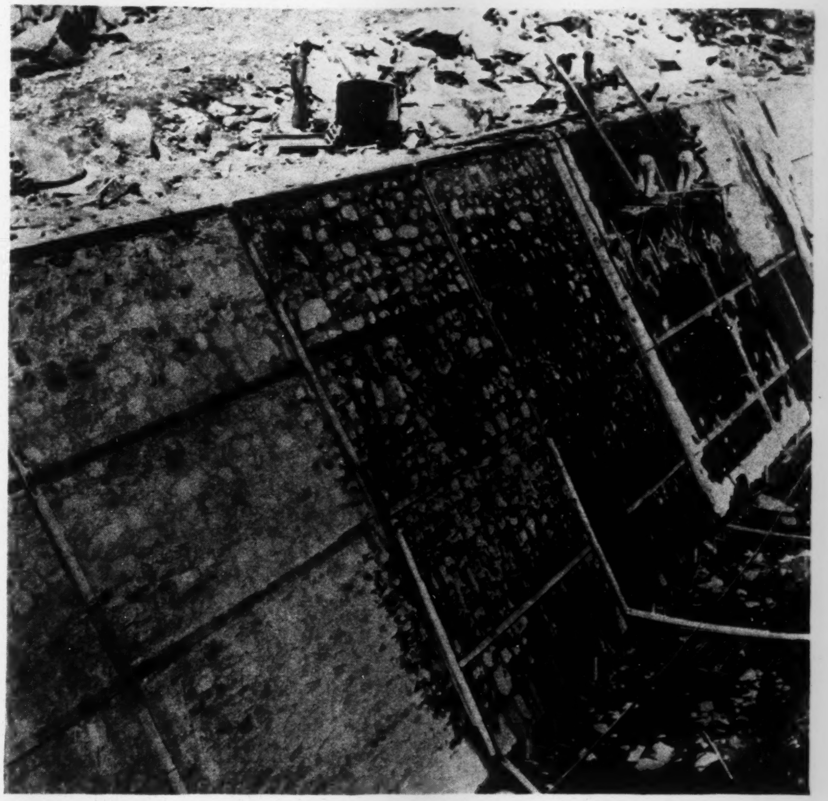
The dam is a rockfill structure located at an elevation of 9,657 ft., across the canyon of East Beaver Creek and about 25 miles southwest of Colorado Springs. The sides and bottom of the canyon are solid granite but of two formations that meet in a 6- to 10-in. seam under the left abutment. The seam is filled with an impervious clay. The excavation to solid rock ranges in depth from the grass roots to about 10 ft. As shown by the plans, the crossing of the canyon called for a dam 580 ft. long on top, 279 ft. long at the toe wall and 100 ft. high from the bottom of the toe wall to the crest. Other details of the structure are shown by the illustrations.

Rockfill

All surface materials were excavated to solid formation and deposited adjacent to the outer toe stakes to be used as backfill against the downstream face. Small stones and waste from the quarry were deposited in like manner. All drainage pipes and outlet conduits were placed on solid granite and incased with concrete; all drainage trenches were filled with broken rock.

Rockfill—The loose rockfill was started at the back portion of the dam, building longitudinally across the valley in lifts 14 to 16 ft. deep and about three-quarters the base of the dam in width. At the quarry, located below the dam at the right abutment, the broken rock was loaded into trucks by a steam shovel, conveyed to the fill and dumped over-end toward the left abutment. This quarry-run rock ranged in size from fines to 5 cu.yd. A shovel on the upstream side of the fill followed, picking up and casting the larger and selected rocks toward the water face of the dam in lifts of about 4 ft. and in widths of about 30 ft.

On the upstream side of this fill was built the derrick and hand-placed dry-rubble wall, of selected 3- to 5-cu.yd. rocks; all voids were filled with small stones, well pounded into place. This is the backing for the rubble-masonry facing wall and was carried up from a width of 12.5 ft. at the base of the fill to 4 ft. at the top.



Close view of facing wall, showing rubble masonry, plaster coating and steel facing work in progress.

Face and toe walls

The upstream face of the rockfill is built from selected rock of nearly cubicle shape, with all the edges trimmed, placed in horizontal broken layers and laid in cement and sand mortar. The bottom, which rests upon the top of the concrete toe wall, is 8.5 ft. wide gradually decreasing to 2 ft. at the top of the dam. This wall is faced with a coat of cement and sand mortar, 2 in. thick and given a sidewalk finish upon which to rest the steel plates. Along the joint lines, longitudinal and vertical timbers were fastened to the rubble wall, and the mortar facing coat was finished flush with the tops of the timbers. These timbers were later removed, leaving grooves for the bolt heads, thus permitting the plates to rest upon a smooth surface.

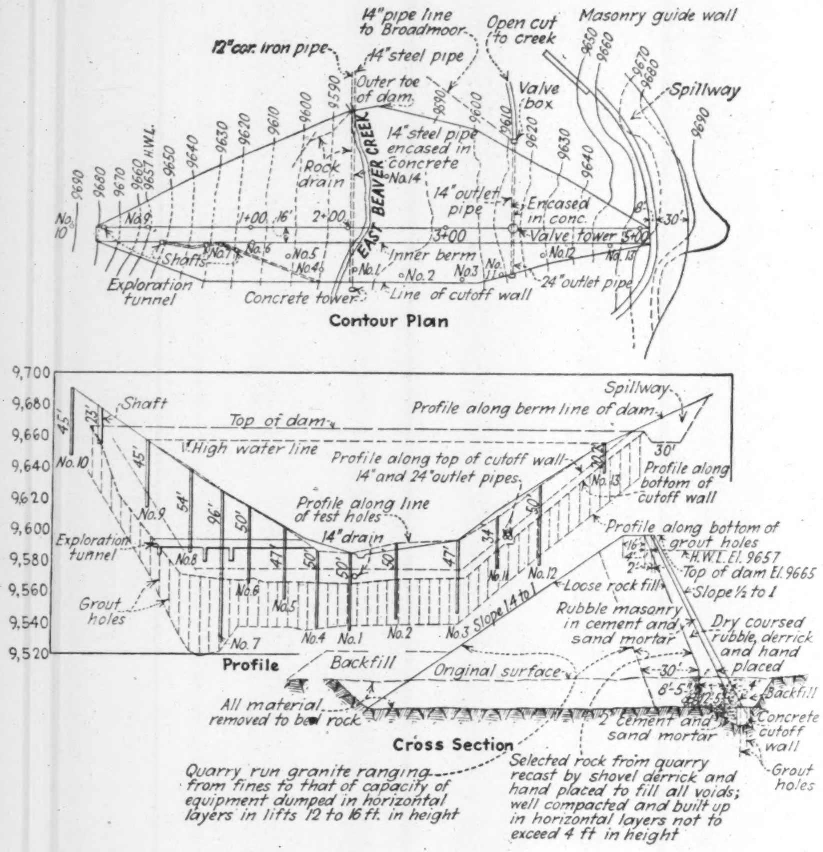
The concrete toe-wall trench was excavated to a minimum depth of 6 ft. in solid granite at the right abutment and across the valley; the depth at the left abutment ranged from 10 to 25 ft. The width of the trench ranged from 6 to 10 ft.

In advance of pouring the toe-wall concrete, two rows of 2½-in. pipe were set vertically, the lower end resting on the bottom of the trench and the upper end projecting 2 ft. above the top of the toe wall. The pipes were spaced 3 ft. apart laterally and 10 ft. apart longitudinally and were staggered to give a drill hole every 5 ft. except at the contact between the different kinds of rock, where the holes were placed 3 ft. apart and both laterally and longitudinally staggered for a length of 25 ft. across the contact. When work closed for the winter the holes, 84 in number, were grouted under a pressure from 100 to 200 lb. per sq.in. A total of 186 bags of cement was used, the average per hole being 1.97 bags; the maximum used on a single hole was 15.5 bags (caused by being forced to the surface before the crevices were plugged), and four holes required five bags each.

The concrete was poured in two operations: first, section ABCDEFA, and second, section BGDCB, after the bottom rows of plates and anchors were placed. The concrete was poured in blocks of 12-hour run, ranging from 30 to 50 ft. in length. Work planes were sealed with copper waterstops and grouting.

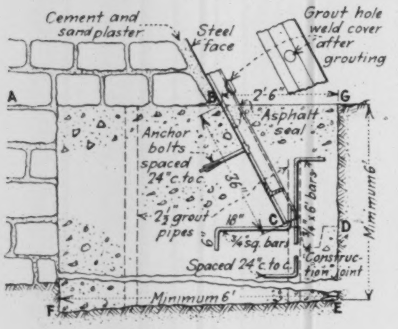
Steel facing

For watertightness, structural-steel plates 20 ft. long and 8½ ft. wide, containing not less than 0.2 per cent copper, were used. The plates were ⅜ in. thick for three tiers, $\frac{5}{16}$ in. for five tiers and ¼ in. for five tiers, to the top of the steel at the crest of the dam. All plates are lapped at longitudinal joints 2½ in., the upper edge of the lower plate resting upon the lower edge of the plate next above in order to give a downward weld. Along the longitudinal joints a ¾-in. bolt is placed every 18 in. to fasten the plates together. In like manner similar bolts are placed at vertical joints joining the plates, with a contraction joint at one end of the plate and with a 6½x6½-in. 19.8-lb. T-section at the opposite end of the plates, thus giving a contraction joint each 40 ft. 7 in. and a T-section each 40 ft. 7 in. for the full length of the steel face.



12" cor. iron pipe
14" pipe line to Broadmoor
14" steel pipe
Open cut to creek
Masonry guide wall
Spillway
Outer toe of dam
Valve box
14" steel pipe encased in concrete No. 14
Rock drain
EAST BEAVER CREEK
14" outlet pipe
Encased in conc.
Valve tower
Inner berm
Shafts
Exploration tunnel
Concrete tower
Line of cutoff wall
24" outlet pipe
No. 10
No. 9
No. 5
No. 4
No. 1
No. 2
No. 3
No. 12
No. 13
1+00
2+00
3+00
5+00
30'
9690
9680
9670
9660
9657 H.W.L.
9650
9640
9630
9620
9610
9600
9590
Contour Plan
9,700
9,680
9,660
9,640
9,620
9,600
9,580
9,560
9,540
9,520
Shaft
Top of dam
Spillway
Profile along berm line of dam
High water line
Profile along top of cutoff wall
14" and 24" outlet pipes
Profile along bottom of cutoff wall
Profile along line of test holes
14" drain
Exploration tunnel
No. 8
No. 6
No. 7
No. 11
Grout holes
Profile along bottom of grout holes
45'
23'
54'
96'
50'
47'
34'
Profile
H.W.L. El. 9657
Top of dam El. 9665
Slope ½ to 1
Loose rock fill
Rubble masonry in cement and sand mortar
Dry coursed rubble, derrick and hand placed
Slope 1.4 to 1
Backfill
Original surface
All material removed to bed rock
2 cement and sand mortar
Concrete cutoff wall
Grout holes
8'-5"
30'
Cross Section
Quarry run granite ranging from fines to that of capacity of equipment dumped in horizontal layers in lifts 12 to 16 ft. in height
Selected rock from quarry recast by shovel derrick and hand placed to fill all voids; well compacted and built up in horizontal layers not to exceed 4 ft in height

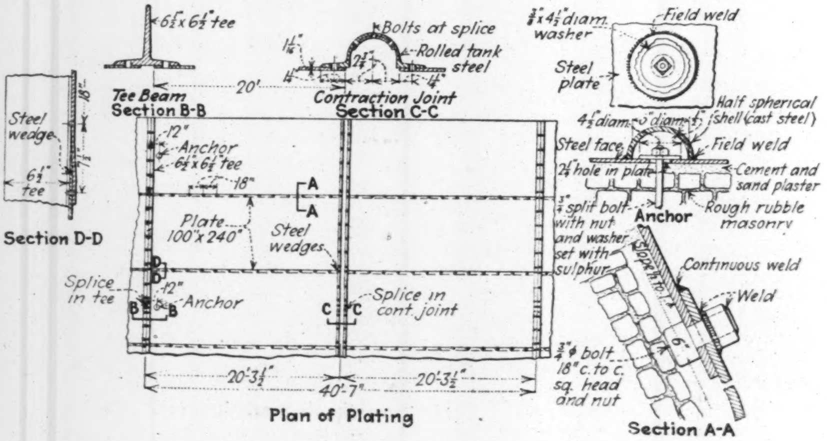
Rockfill dam with welded steel-plate facing for the new $700,000 water-supply system for the Broadmoor Hotel in Colorado.



Cement and sandplaster
Steel face
Grout hole weld cover after grouting
A
B
G
2'-6"
Asphalt seal
Anchor bolts spaced 24" c. to c.
36"
18"
2½ grout pipes
¾ sq. bars
C
D
½ x 6' bars
Minimum 6'
Construction joint
Spaced 24" c. to c.
Minimum 6'
F
E
Y

Toe wall concreted in two sections to embed lower part of steel facing and all supporting and anchoring steel.

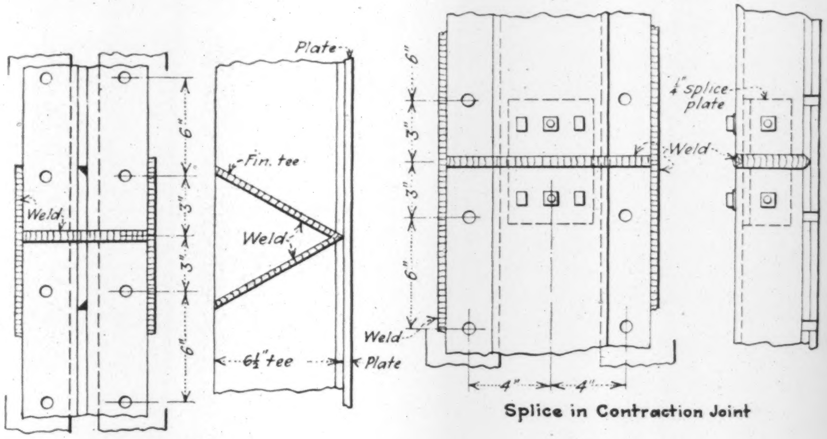
Erection—When the rubble masonry face had reached a height of 30 ft. the contraction joint and T's were let down from the top of the fill at the midway point of the dam by means of a winch and cables and brought to approximate position. Then the bottom row of plates, loosely bolted together, was dropped to place in the toe wall, resting upon the protruding Z-bars, previously placed for that purpose, after which all bolts were placed but not tightly set. In like manner a second and third row were dropped to place and loosely bolted. Following this, the tops of the contraction joint pieces and the T's were pitched forward, leaving a space between the face of dam and the plates and held in position by wood-box wedges of different sizes. Workmen were then lowered, one between the face of the dam and plate to hold the bolt, and one outside to set the nut. This operation was continued until all bolts were given the final set, eight rows in length, when arc-welding was begun on all joints, bolt heads and anchor coverings, for the full length of the steel face.



6½x6½ tee
Tee Beam Section B-B
Bolts at splice
Rolled tank steel
Contraction Joint Section C-C
20'
Steel wedge
6½" tee
Section D-D
12"
Anchor 6½x6½ tee
18"
Plate 100"x240"
Steel wedges
A
A
D
D
Splice in tee
B
B
Anchor
C
C
Splice in cont. joint
20'-3½"
40'-7"
20'-3½"
Plan of Plating
⅞x4½" diam. washer
Field weld
Steel plate
Half spherical shell (cast steel)
4½" diam.
Steel face
2¼ hole in plate
Field weld
Cement and sand plaster
Rough rubble masonry
¾ split bolt with nut and washer set with sulphur
Anchor
Continuous weld
Weld
Slope ½ to 1
6"
¾" ϕ bolt 18" c. to c. sq. head and nut
Section A-A

Steel facing, showing T-beams, contraction joints, plating bolts and all welds at joints and bolts.

Plate Anchorage—At one side, 12 in. from the center of each T-section, is placed a ¾-in. bolt, 16½ in. long (split end and key at bottom, washer and nut at the top), in a hole drilled into the rubble masonry face wall and set with sulphur. This bolt is inserted through a hole 2¼ in. in diameter, drilled through the plate at the shop, and resting on the plate is a washer 4¼ in. in outer diameter, thus leaving a 1½-in. play. The nut was set and welded over the top. Covering all is a half spherical shell of cast steel with a fillet weld fastening it to the plate. These anchor bolts are placed at each T, spaced longitudinally 40 ft. 7 in. c. to c., and at each two rows of plates vertically, where they are spaced 16¼ ft. c. to c.



Splice in Tee

Splice in Contraction Joint

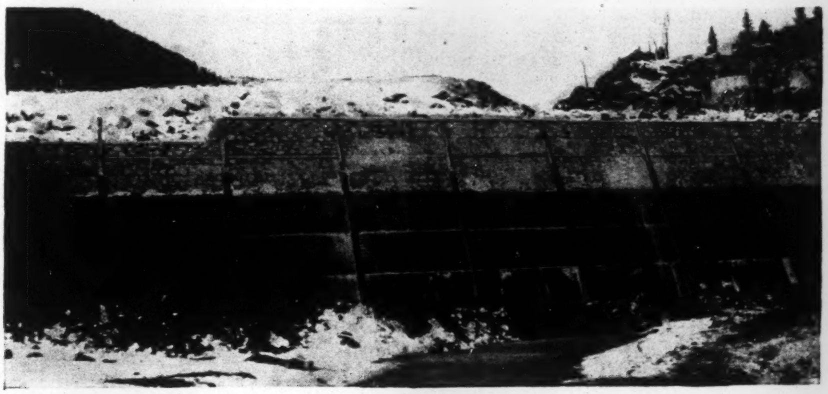
Diagram of welded splices of T-beams and contraction joints.

Pipe line

The reservoir formed by the dam has a capacity of 56,000,000 cu.ft. The area feeding this basin is 6.1 square miles, located in the zone from 9,657 ft. at the reservoir to 12,000 ft. on Bald Mountain a spur from Pikes Peak. The topography is steep mountain sides well timbered; practically all on the U. S. Pike Forest, with but few habitations and all under rigid control by the United States Forest Service. The water is clear, cold, soft and free from organic and other objectional matter, requiring no filtration, aeration or purification by use of chemicals.

For conveying the water from the reservoir to the Broadmoor Hotel and vicinity a steel pipe, plain end, joined together with Dresser couplings, is used. From the reservoir to a low divide between the west and east drainage of the Pikes Peak range, a distance of 2 miles, a 13-in. pipe is used. Here the pipe is laid through a tunnel 430 ft. long. Thence a pipe 10 in. in diameter runs 9¾ miles to the northern slope of Cheyenne Mountain overlooking Broadmoor and the plains eastward.

This reservoir and the pipe-line work, now under construction and about 75 per cent completed during 1931, will cost about $700,000.

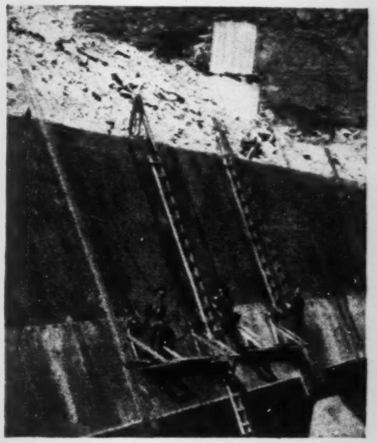


Upstream face of rockfill dam, showing facing wall and steel-plate facing completed to part height.

Personnel

The late I. A. Keyte, professor of geology at Colorado College, Colorado Springs, and at a later date Ira A. Williams, consulting geologist of Portland, Ore., were called for consultation and reports on the dam. Frank M. Okey, professor of civil engineering, Colorado College, has charge of compression and permeability and control tests of concrete and cement. All cement was tested and certified by the Pearce Testing Laboratories, Denver, Colo. The state engineer, M. C. Hinderlider, by statute, will approve all plans of this nature before construction work begins and will act as consulting engineer during construction. Frank P. McKibben, consulting engineer, of Schenectady, N. Y., was consulting engineer for the steel-plate facing and prepared the welding specifications. Edward H. Honnen, of Colorado Springs, was awarded the contract for both the rockfill dam and the pipe line. The American Bridge Co. was awarded the contract for the steel facing, furnishing the materials, fabrication, shop plans, erection and welding, complete in place. The Sullivan Machinery Co., of Chicago, drilled all holes for testing the foundation and for grouting.

Welding crew worked from staging hung from top of facing wall.



Close view of contraction joint with welded U-plate cover and adjacent plating bolts and joints welded.

The design of the system was made by J. H. Sanford, engineer in charge of construction, and the writer, who is consulting engineer of the work.

Tests Provide New Data on Concrete-Column Design

Studies of reinforced-concrete columns at Lehigh and Illinois give quantitative measure of plastic flow and load redistribution, as well as a basis for allocating load to the spirals—Sustained working loads do not impair ultimate strength of columns

DURING the past two years there has been under way jointly at Lehigh University and the University of Illinois the most comprehensive investigation ever undertaken of the reinforced-concrete column. The investigation is being carried on by a committee of the American Concrete Institute, financed by various companies and organizations. About 600 columns are involved. Previous to the current investigation, a period of fifteen years had elapsed since the results of an extensive series of column tests had been published in the United States. The general purpose of the present column study is to establish the fundamental relationship between the load, elastic properties and ultimate strength as affected by such factors as quality of concrete, amount and quality of longitudinal and lateral reinforcement, rate and method of applying load, effect of continuous loads over long periods of time and size of columns. —EDITOR.

SIGNIFICANT and new knowledge concerning concrete-column behavior has been developed by the extensive research studies that have been carried out during the past two years at the laboratories of Lehigh University, Bethlehem, Pa., and the University of Illinois, Urbana. The new element in the tests concerns the effect of long-time loading, which has never previously been studied in a comprehensive manner. Confirmation of earlier findings regarding spiral action, the division of load between the component parts of a reinforced column and scale effect between large and small columns also form a valuable contribution of the current program.

The same test procedure and type of specimen were used by both laboratories, so that two sets of results have been obtained in most cases. Practically all data collected to date have been published. Some conclusions have been given, others are evident from a study of the data. It is clear that spiral reinforcement contributes much more strength to a column than has often been utilized and that this strength may be closely estimated. Although the toughening effect of spiral reinforcement has long been recognized, there has been disagreement as to how this should be utilized in design. These tests bring out that weight-for-weight spiral reinforcing is from one to two times as effective in increasing ultimate column strength as is longitudinal steel. At Illinois the average factor for hot-rolled rod was 2.19, the lowest being 1.70. At Lehigh the values were lower, from 0.7 to 2.3, apparently due to the use of a free spherical bearing block at the top of the columns. At Illinois the bearing block was wedged against turning. In general, columns with drawn wire-spirals fail suddenly, while with hot-rolled rod spirals the failure is gradual and the spirals do not break at the maximum load. Another indication of the tests that will prove useful to designers is that the strength of a reinforced-concrete column may be assumed to be made up of: (1) the strength of a plain concrete column (found to be 75 to 85 per cent of the control cylinder strength) rated on the net area of concrete within the outer circumference of the spiral; (2) the yield-point stress of the longitudinal steel times its area; and (3) the total yield-point strength of the spiral times an effectiveness factor of 1 to 2. Thus the longitudinal steel was found to be 100 per cent effective (as measured by yield point) in contributing to column strength. Since the spiral is even more effective in this respect, the importance of the steel reinforcement becomes plainly evident. Scale effect between the 8-in.-diameter columns (most of the test specimens) and a small number of 12-, 20- and 28-in. columns was not important, all columns following the same general laws.

Perhaps the most important data of the tests involved a quantitative measure of stress redistribution between concrete and steel reinforcing under load—in other words, the effect of shrinkage and flow. Steel stresses in some cases increased two or three times in columns held under load during a year; the concrete stress decreased correspondingly. Most of the stress transfer had taken place at the end of five months. However, the stress redistribution did not affect the ultimate strength of the columns, for loaded columns tested to failure at the end of the year showed a strength quite as high as unloaded companion columns. In the unloaded columns the shrinkage created a compression in the steel with a corresponding tension in the concrete—in one case of 450 lb. per sq.in., but without evidence of cracks in the concrete.

Specimens and testing procedure

Most of the columns tested were 8 in. in diameter and 5 ft. long, although Illinois included two series of tests on 12-, 20-, and 28-in. columns. Cement for all tests was obtained from the same mill. Trial mixes with the aggregate available to each laboratory determined water-cement-strength curves, which were used in designing the mixes for the various columns. As a result of preliminary tests (series 1), plain-end

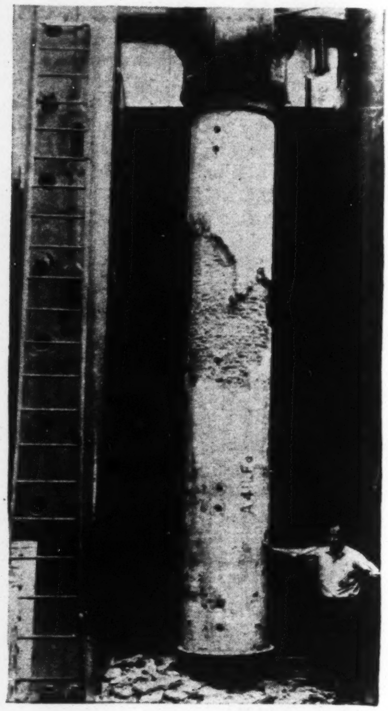


Fig. 1—Typical failure of one of the largest columns tested, 32 in. in outside diameter, about 18 ft. long and weighing 8 tons. Tested in the 3,000,000-lb. testing machine at the University of Illinois, these large columns were found to follow the same general laws determined from the 8-in.-diameter column tests that formed the principal body of the program.

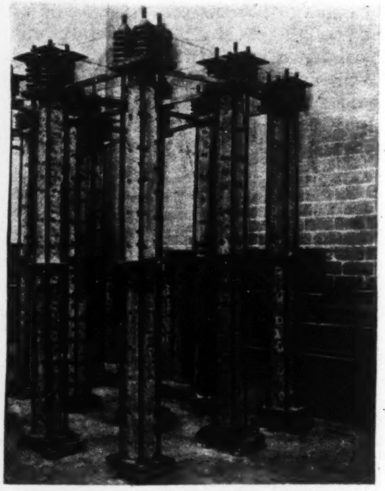


Fig. 2—Columns in the long-time loading rig at the University of Illinois. The springs were calibrated for the desired loads, and the rods were manually tightened accordingly. At Lehigh the columns and rig were placed in a testing machine to apply the required load.

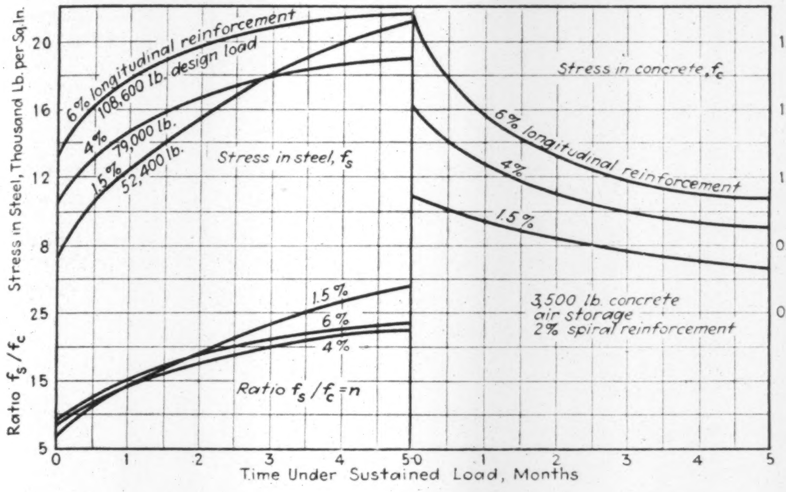


Fig. 3—Distribution of stresses in concrete and steel of the columns at the Illinois laboratory during a five-month loading period. Change in column deformation and steel stresses was greatest for low percentages of longitudinal steel. Concrete stresses fell off rapidly as the yielding of concrete progressed. Note that values of n increased 300 per cent by the end of the five months.

columns were selected for the main body of tests, since columns with capitals were found to develop high bending stresses, with failure localized near the top, and were difficult and expensive to make. Also, continuous longitudinal reinforcement, with the bars flush with the concrete top and bottom, was found to give the best and most consistent results, and this arrangement was adopted for the remainder of the tests.

In another set of tests (series 2) the rate of applying load was studied in the belief that, if a comparatively long period of time elapsed between increments of loading, resulting plastic deformation might affect the carrying capacity of the column. The customary method of applying the load, denoted as "fast loading," allowed about 15 min. or less between the application of increments of load. In "slow loading" three-quarters of the ultimate load was applied in increments as a "fast load," and the remainder was applied in six to ten increments applied at intervals of four hours. During the four-hour periods the load on the column was held constant by means of a bed of springs upon which the column was mounted, or by continuous operation of the testing machine. While greater changes in the length of the columns occurred under slow loading, ultimate strengths were practically the same as for fast loading. Fast loading consequently was adopted for the remainder of the tests except for one set (series 7) at Illinois, where slow loading was used.

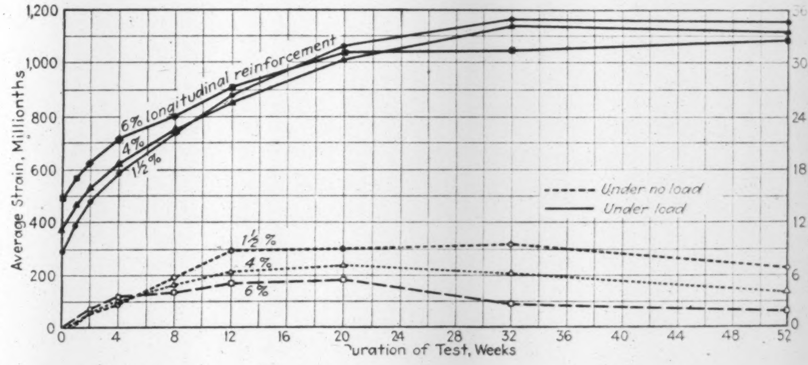


Fig. 4—Deformation of dry-storage columns having various percentages of longitudinal reinforcement at Lehigh.

Test procedure for the principal body of tests—those involving the holding of working loads for a year or more—was simple but effective. Companion columns both plain and reinforced were made for the main series of tests; some of each of these, loaded and unloaded, were kept in a moist room. Some of each type were also kept unloaded in the air of the laboratory for comparison with the loaded columns. In general, for each mix and reinforcement two columns were loaded and two were stored under no load. The loaded columns were placed one on top of the other so that a loading rig served two columns. The loading rig was composed of three or four helical springs at the top of the column connected to a bearing plate on the bottom of the columns by means of three or four 1¼-in. rods 12½ ft. long. At Lehigh the load was applied by inserting columns and rig in the testing machine and bringing the head of the machine down upon an upper plate bearing on the springs. When the required load was reached, the springs were fastened in their compressed condition by tightening nuts on the bottom of the 1¼-in. rods, and the columns were then removed from the machine to laboratory or moist-room storage. At Illinois the springs were calibrated and the nuts tightened by hand until the required shortening of each spring was produced.

Test procedure for the large columns at Illinois followed usual methods except that the size of the columns precluded their being placed in a moist room and necessitated curing under wet burlap. They were tested in a 3,000,000-lb. testing machine.

Scope of tests

Seven series of tests are included in the test program. Of these, all but

Fig. 5—Effect of one-year loading period on stresses in steel and concrete of columns of two different concrete strengths at Lehigh.

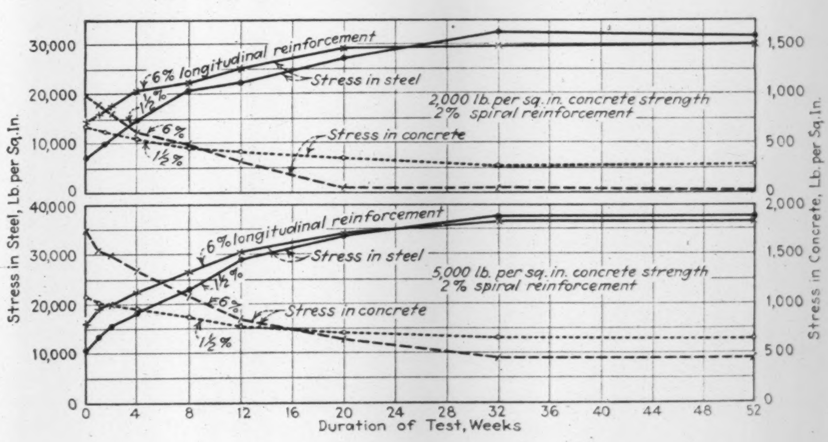


TABLE I — PROGRAM OF TESTS FOR COLUMN INVESTIGATION

Series	Dia., In.	Concrete Strength, Lb. Per Sq.In.			Reinforcement								
					Longitudinal					Spiral			
					Grade	Per Cent				Grade	Per Cent		
1	8		3,500		Interm.			4		Interm.		1	
2	8	2,000	3,500	5,000	Interm. Struct. Rail	0		4		Interm.	0	1	
			3,500		Interm.	0	1½	6		Interm.		1	
			8,000		Interm.	0	1½	4	6	Interm.	0	1	
3	8	2,000	3,500	5,000	Interm.			4		Interm.	0	1	2
		2,000	3,500	5,000	Interm.		1½		6	Interm.			2
			3,500		Interm.		1½		6	Interm.	0	1	
			3,500		Interm.		1½		6	Interm.			2
4	8	2,000	3,500	5,000	Interm.			4		Interm.	0		2
		2,000	3,500	5,000	Interm.			4		Interm.	0	1	2
		2,000	3,500	5,000	Interm.		1½		6	Interm.			2
		2,000	3,500	5,000	Interm.		1½		6	Interm.			2
5	12	2,000	3,500		Interm.		1½	4		Interm.		1	
	20	2,000	3,500		Interm.		1½	4		Interm.		1	
	28	2,000	3,500		Interm.		1½	4		Interm.		1	
6	8*a*	2,000	3,500		Interm.			4		Interm.		1	
	12*a*	2,000	3,500		Interm.			4		Interm.		1	
	20*a*	2,000	3,500		Interm.			4		Interm.		1	
	28*a*	2,000	3,500		Interm.			4		Interm.		1	
7	8		3,500		Interm.	0	1½			High Y. P.		1	
			3,500		Interm.	0	1½	4		High Y. P.			2
			3,500		Interm.	0	1½	4		Interm.			2

General Note: In all cases the length of column is 7.5 times the diameter.
a: Diameter of spiral. 2-in. shell outside spiral.

series 4 at Lehigh, involving the effect of the maximum load a column will sustain indefinitely, have been substantially completed. An exception is a group of both plain and reinforced-concrete columns under working loads saved for observation during the second year, this observation being in the nature of a study of the magnitude of the changes in stress distribution caused by shrinkage and plastic flow of the concrete. The complete test program is given in Table 1. Briefly, the purpose of the several series may be summarized as follows:

Series 1—A study of end connections to determine the best type of end detail to use in the program.

Series 2—Study of the effect of the strain on the ultimate strength of the column of holding load increments for four hours, the load being applied by both a fast and a slow method. The series included a wide variation in quality of concrete and in amount and kind of reinforcing steel.

Series 3—Study of effect of sustained working loads on deformation and strength, with final determination of strength of the column. The effect of shrinkage and plastic flow was an important element studied in this series of tests.

Series 4—Study of the effect of the maximum load a column will sustain indefinitely. Except for the magnitude of the load and the length of time under load, this series is much the same as series 3.

Series 5—Study of the effect of scale between small test columns (8 in. in diameter by 60 in. long), and columns of the size used in building construction (12-, 20- and 28-in. core diameters, with a height equal to 7½ times the core diameter).

Series 6—Similar to series 5 but with a 2-in. protective shell around the spiral reinforcement. (In all other series no protective shell of concrete was used outside the spirals.)

Series 7—Study of the effect of high-yield-point wire spirals on the strength of reinforced-concrete columns. For comparison, columns having intermediate-grade steel spirals were also included.

Elements of column strength

As stated previously, series 1 and 2 were basically preliminary to the remainder of the program, series 1 determining the type of column to be tested and series 2 the method of loading. Series 2, however, had a broader purpose—namely, of determining the effect on column strength of kind and amount of reinforcement and of quality of concrete. Concretes of 2,000, 3,500 and 5,000 lb. per sq.in. at 56 days were used, and three grades of longitudinal steel in percentages of 1½, 4 and 6 were utilized, with about 1¼ per cent of intermediate hot-rolled steel spirals. Thus, the results represented a rather wide range of column types.

The results provided a definite quantitative measure of the contribution that each of the elements of a reinforced-concrete column—concrete, vertical steel and spiral—makes to total ultimate strength. Both laboratories agree that this ultimate strength equals net concrete core area times 75 to 85 per cent of the control cylinder strength, plus vertical steel area times its yield-point stress, plus *equivalent* area of spiral rod times its yield-point stress times the effectiveness ratio. (The equivalent area of spiral is assumed to be equal to the area of vertical steel having a volume of steel per unit length of column equal to that of the spiral reinforcement used.) Among the results obtained in series 2, which support this definition of column strength, were the following: (1) strains measured on the steel agreed well with those measured on the concrete for all columns tested; (2) regardless of grade of vertical steel used, the increase in total column strength due to the use of vertical steel equaled its yield-point stress times its area; and (3) the average strength of unreinforced columns was 75 to 85 per cent of the strength of the cylinders, while the concrete in the core area of a reinforced column equaled about 100 per cent of the strength of a plain column.

Effect of spiral reinforcement

In all tests of series 1 to 6 spirals of hot-rolled rod were used exclusively to avoid any variable from this score. In series 7, however, a separate study was made of high-yield-point spiral, using a cold-drawn wire. Columns with intermediate-grade spiral were included in this series for comparison. Concrete strength and grade of longitudinal reinforcement were maintained constant throughout series 7. Further verification was obtained in this series of the fact that the strength added by spiral steel is about twice the strength added by an equal amount of longitudinal steel of the same yield-point stress. The high-yield-point spiral thus produced a stronger column. On the average the drawn-wire spirals were found to be (at Illinois) 1.99 times as effective in producing ultimate column strength as an equal weight of vertical steel of the same quality, while the corresponding figure for intermediate-grade hot-rolled rod spirals was 1.66 at Lehigh and 2.19 at Illinois. The lower values at Lehigh, as stated previously, were attributed to the use of a free spherical bearing block.

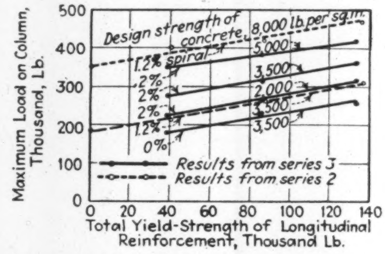


Fig. 6 — Effect of total yield-point strength of longitudinal reinforcement on ultimate strength of columns at Lehigh.

The drawn-wire appeared to be especially effective in adding toughness to the column. At Lehigh the variation in the amount of grade of spiral had practically no effect on deformation up to the yield-point strength of the columns. At Illinois this was also found to be true, but here the strain readings were continued until the columns failed. Columns with 2 per cent of drawn-wire spiral shortened as much as 1.6 per cent at failure, while columns with the same amount of hot-rolled rod spiral shortened only 0.7 per cent. Since the increase in strength of a concrete core above its plain concrete strength is proportional to the lateral pressure that the spiral can exert upon it, it follows that, to exert a high pressure, drawn wire must stretch a large amount because of its high strength. The large increase in lateral strain of such a column is thus of necessity accompanied by a correspondingly large shortening of the column.

Tests of large columns

In order to determine what scale effect, if any, existed between the small 8-in.-diameter test columns and columns of a size suitable for actual buildings, about 35 columns of 12-, 20- and 28-in. core diameter were tested at Illinois. All of these large columns had a height equal to 7½ times their core diameters. Twenty columns had no shell of concrete outside the spiral (series 5), while the remainder of the columns (series 6) were inclosed in a shell 2 in. thick. In series 5 the effectiveness of the spiral was rather variable (attributed to less perfect workmanship than used in the 8-in. columns), but the effectiveness factor averaged 1.99 as compared with a value of 2.07 for fifty 8-in. columns tested in series 2, using the same grade of spiral steel. As there was no consistent variation in strength with size of column, it was concluded that the large columns followed the same general laws as the small 8-in. columns.

In general, columns with protective shells were as strong as the unincased columns, except for the 8- and 12-in.-diameter columns, in which the strength of shell was greater than the margin of strength produced by the spiral. The shell concrete was at least 75 per cent effective (as compared with the control cylinder strength) except for the 8-in. columns, in which openings cut for strain-gage lines reduced the effective shell area considerably.

In all of these large columns a gradual quiet failure was observed, similar to the failure of the smaller columns in other series in which intermediate-grade spirals were used.

Columns under long-time loads

The most extensive of the several groups of tests and probably the most important from a column-design standpoint was designated as series 3 and was planned to study the effect of a sustained working load on column deformation (from shrinkage and plastic flow) and on ultimate strength. Results are available for a five-month and a one-year period. At Illinois eighteen plain and twenty-six reinforced-concrete columns, and at Lehigh twelve reinforced columns are being maintained under load for a second year. For the 108 reinforced-concrete columns for each laboratory in this series both moist and air storage were used for both the loaded and the unloaded companion specimens. Concrete was designed for three different strengths at 56 days—2,000, 3,500 and 5,000 lb. per sq.in. Three percentages of vertical steel (1.5, 4 and 6) and two percentages of spiral steel (1.2 and 2) were used. None of the columns had an appreciable shell outside the reinforcement. Working loads were computed by both the A.C.I. code and the New York City code, although some of the columns do not adhere in their make-up to all the restrictions of these codes. The method of holding the loads for the long-time tests by means of helical springs has been described.

Flow and shrinkage results

Observations were taken on the columns continuously, and results were reported at five months and one year. Tables II and III, on p. 768, for Illinois and Lehigh, respectively, are compiled from data given in these reports and show the changes in steel and concrete stresses throughout the period due to shrinkage and flow. For the unloaded columns the tables show forcibly the effect of shrinkage in placing tension in the concrete.

It is strikingly evident that in the loaded columns the flow and shrinkage strains during the first five months greatly increased the steel stresses and substantially reduced the concrete stresses. But it is also plain that during the succeeding seven months the stress redistribution was much less rapid. In spite of the large increase in steel stresses, in only a few of the cases was 50 per cent of the yield-point stress exceeded. At Illinois the greatest observed steel stress after one year was 30,800 lb. per sq.in.; in this same column the steel stress, at time of applying the load, was 11,100 lb., and at the end of five months it was 25,500 lb. At Lehigh the steel stress increased during the year from 6,000 to 37,000 lb. per sq.in. for columns having 1½ per cent vertical steel. It is particularly important to note that, while the initial stresses in the concrete and steel may

Fig. 7—Stress-deformation diagram for concrete during cycle of loading at Lehigh. *AB* represents period of initial loading; *BC*, flow of concrete under load and *CDE*, period of release of load. Abrupt break at *D* is point at which concrete ruptured. *DE* is maximum width of crack. The parallelism of the various curves in each diagram indicates that the elastic properties of the concrete were not affected by the amount of spiral reinforcement. Other test data indicated that columns having the greatest percentages of longitudinal steel showed the greatest maximum width of cracks per unit length of column after load was released

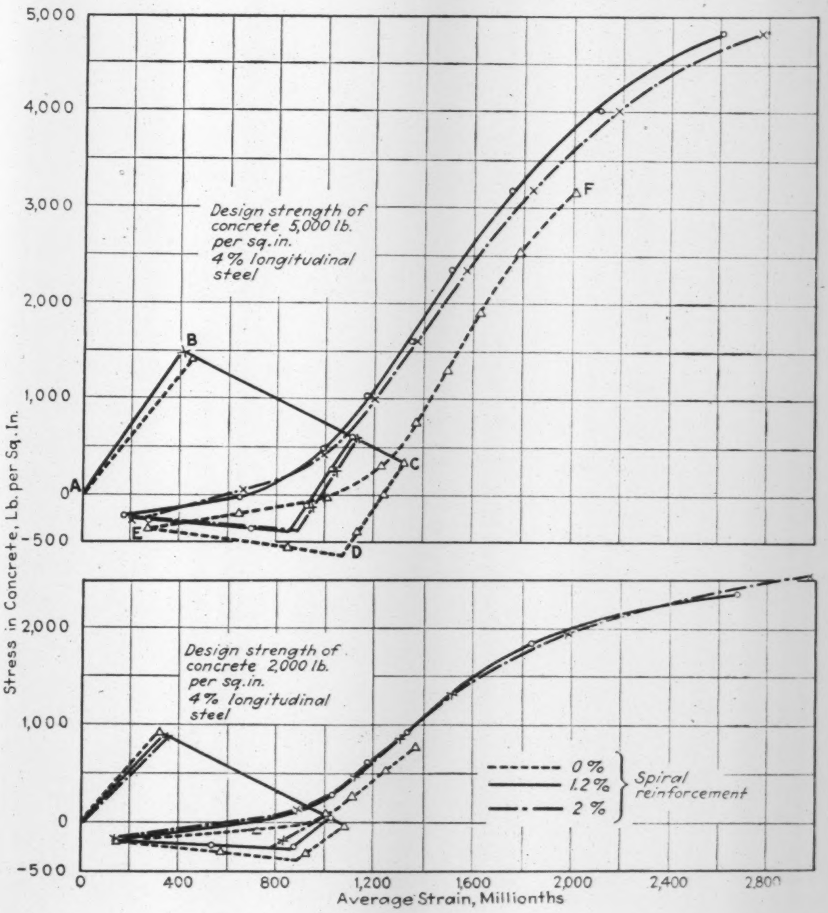


TABLE II — STRESSES IN AIR-STORED COLUMNS FROM MEASURED STRAINS AT ILLINOIS

Unit stresses, f_s in steel, and f_c in concrete, are in lb. per sq.in. Positive values are compressive stress; negative values, tensile stress.

Nominal Column Design				Loaded Columns						Unloaded Columns			
Concrete Strength, Lb. per Sq.In.	Per Cent Reinforcement		Design Load, Lb.	At Load Application		After 5 Months		After 1 Year		After 5 Months		After 1 Year	
	Vertical	Spiral		f_s	f_c	f_s	f_c	f_s	f_c	f_s	f_c	f_s	f_c
2,000	1	2	38,000	7,300	650	19,600	455	21,200	430	5,600	—89	4,700	—75
	4	0	37,200	4,300	685	10,800	325	11,400	300	.....	....	2,600	—55
	4	1	64,000	9,400	940	16,000	665	19,200	530	1,200	—50	1,200	—50
	4	2	64,000	12,100	825	20,400	480	20,300	485	1,600	—66	900	—20
	6	2	90,000	12,200	1,130	20,400	610	22,600	475	800	—50	500	—15
3,500	1	0	47,200	6,400	855	19,100	650	22,400	600	.....	....	.....	..
	1	1	52,400	9,800	905	20,000	740	25,400	650	.....	....	.....	..
	1	2	52,400	7,000	945	21,100	725	26,700	635	4,300	—68	4,200	—65
	1	2	67,000	11,100	1,175	25,500	945	30,800	865	.....	....	.....	..
	4	0	55,200	6,500	870	16,300	470	17,000	440	3,400	—140	1,900	—40
	4	1	79,000	9,800	1,230	20,000	810	22,200	715	2,600	—108	2,200	—90
	4	2	79,000	10,200	1,210	19,000	850	20,600	780	2,800	—116	800	—15
	6	0	81,200	6,000	1,335	13,700	850	14,500	800	.....	.....	.....	..
	6	1	108,600	12,400	1,515	24,800	730	23,100	835	.....	.....	.....	..
	6	2	108,600	13,100	1,470	21,600	930	23,500	820	.....	.....	—1,000	60
	6	2	75,200	8,300	1,065	13,400	740	15,000	640	.....	.....	.....	...
5,000	1	2	59,400	7,300	1,080	22,100	850	23,200	830	7,200	—114	6,700	—110
	4	0	72,000	8,600	1,130	20,000	660	21,600	600	3,900	—161	3,200	—65
	4	1	96,000	10,600	1,550	23,000	1,040	25,000	950	3,700	—153	1,700	—70
	4	2	96,000	9,000	1,620	21,100	1,115	23,300	550	4,700	—194	3,300	—70
	6	2	130,400	15,500	1,780	27,100	1,045	25,200	1,170	5,000	—316	2,100	—65

be assumed to be proportional to their respective moduli of elasticity (and results of these tests bear this out), this proportion does not hold after shrinkage and plastic flow come into play. Present design practice does not take this fact into account.

Neither the observations at five months nor those at one year indicated that the rate of flow was appreciably affected by different grades of concrete nor by different amounts of spiral, although at Lehigh the one-year deformation was slightly greater for columns of high-strength concrete. However, at both laboratories the deformations and thus the increases in steel stress were largest for columns with the smallest percentage of longitudinal reinforcement. Thus, with 6 per cent vertical steel at Illinois the steel-stress increase was 9,200 lb. per sq.in.; with 4 per cent vertical steel it was 9,700 lb. per sq.in.; and with 1.5 per cent vertical steel it was 13,200 lb. per sq.in. At Lehigh the corresponding increases in steel stresses were 17,000, 20,000 and 23,000 lb. per sq.in. for columns containing 6, 4 and 1½ per cent of vertical steel, respectively.

The redistribution of stresses in the concrete and steel during five months is plainly shown in Fig. 3 for the Illinois results. Not only did the concrete stresses fall off rapidly, but yielding was still apparent at the greatly reduced concrete stresses existing after a two-month period. The lower curves in the figure show how values of the ratio of steel and concrete stresses varied. After five months of loading the values are three times as great as the initial values, which are in close agreement with the theoretical value of *n*.

The redistribution of stresses between steel and concrete during the twelve-month period at Lehigh is shown in Fig. 5. From this diagram it is also evident that the steel stresses were greatest for columns with the smallest percentage of vertical reinforcement. Also, that decrease in concrete stress was greatest for columns with high percentages of vertical steel. Observations on all unloaded columns showed that shrinkage caused a compression in the steel, which resulted in a corresponding tension in the concrete, as is indicated by minus signs in Table II and III.

All of the results given in this article are for air-cured columns, which more nearly simulate actual service conditions. It may be noted, however, that for the columns stored in the moist rooms the increase in steel stress was much less than for those stored in the air of the laboratory.

Ultimate strengths of columns

At the end of the one-year period the columns were tested to failure. In making these tests it was necessary to release the columns from the loading rigs before they could be placed in the testing machine. As a result of this load release, recovery of the large elastic strains in the steel caused tension cracks in the concrete about 1 ft. apart. These cracks, however, closed during tests in the machine when the working load was again reached. No cracks appeared in any of the columns held for a year under no load.

TABLE III — STRESSES IN AIR-STORED COLUMNS FROM MEASURED STRAINS AT LEHIGH

Positive values are compression; negative values, tension.

Nominal Column Design				Loaded Columns						Unloaded Columns			
Concrete Strength, Lb. per Sq.In.	Per Cent Reinforcement		Design Load, Lb.	At Load Application		After 5 Months		After 1 Year		After 5 Months		After 1 Year	
	Vertical	Spiral		f_s	f_c	f_s	f_c	f_s	f_c	f_s	f_c	f_s	f_c
2,000	1½	2	38,400	6,960	670	27,180	340	31,300	280	5,820	—90	3,690	—59
	4	0	64,400	9,480	940	29,160	130	32,300	—4	5,040	—210	3,360	—139
	4	1.2	64,440	10,260	910	29,220	120	30,500	70	6,360	—260	3,660	—151
	4	2	64,400	10,650	890	30,660	60	29,900	95	6,180	—260	2,160	—90
	6	2	90,500	14,550	990	29,460	50	30,000	10	4,320	—270	1,770	—112
3,500	1½	0	49,000	8,940	850	36,180	420	42,400	320	.....	.....	.....	.....
	1½	1.2	49,000	9,360	840	31,590	490	35,300	430	.....	.....	.....	.....
	1½	2	49,000	7,380	870	30,810	500	34,800	440	9,990	—160	7,490	—119
	1½	2	67,500*	11,700	1,180	42,660	690	45,600	640	.....	.....	.....	.....
	4	0	79,500	11,070	1,190	35,100	190	36,800	120	7,230	—300	4,050	—167
	4	1.2	79,500	11,880	1,150	31,140	360	31,800	330	8,040	—330	3,630	—150
	4	2	79,500	11,400	1,170	31,080	360	33,200	270	6,750	—280	3,690	—153
	6	0	109,000	14,640	1,380	32,580	250	35,500	53	.....	.....	.....	.....
	6	1.2	109,000	13,230	1,470	29,880	420	32,400	250	.....	.....	.....	.....
	6	2	109,000	14,700	1,380	31,440	320	31,300	320	5,850	—370	750	—47
	6	2	82,300*	11,100	1,040	28,770	—80	26,200	78	.....	.....	.....	.....
5,000	1½	2	60,300	10,350	1,050	33,690	680	37,000	630	11,250	—180	9,360	—148
	4	0	96,500	13,410	1,440	34,530	570	39,500	360	7,590	—310	6,780	—280
	4	1.2	96,500	12,090	1,520	31,470	690	33,200	620	7,470	—310	4,200	—174
	4	2	96,500	12,330	1,490	31,350	700	37,700	600	8,970	—370	5,220	—216
	6	2	130,600	16,050	1,750	33,750	630	36,400	450	7,170	—450	3,300	—208

*New York loading; all others A.C.I.

The results of these ultimate-strength tests are notable in view of the great redistribution of stress between the concrete and the steel that had taken place during the year under load. At both laboratories it was found that the ultimate strengths of loaded and unloaded columns were almost exactly equal. Thus the sustaining of a working load for a period of 52 weeks had no appreciable effect upon the strength of the column.

In the ultimate-strength tests further verification was secured of the fact that column strength equals 75 to 85 per cent of the control-cylinder strength, plus the total yield-point strength of the longitudinal reinforcement, plus the total yield-point strength of the spiral reinforcement times an effectiveness ratio. The average value of this ratio for the ultimate-strength tests was found to be 2.4 at Illinois. Lower values (2.35 for dry-stored and 1.67 for wet-stored columns) were found at Lehigh, where a free spherical block was used at one end of the columns. At Illinois the columns were tested with both ends flat.

In these ultimate-load tests the columns at Illinois showed a factor of safety, with regard to column yield-point (considered as the load at which the vertical steel reaches its yield point and the concrete has developed its unrestrained ultimate strength), varying from 2.77 to 4.18 for spirally reinforced columns. At Lehigh the values ranged from 2.58 to 5.85.

Test personnel and administration

The investigation was conducted under the direction of committee 105 of the American Concrete Institute, of which the late Prof. W. A. Slater was chairman. The tests were made at Lehigh University and the University of Illinois, under the direction of Prof. Slater and Prof. F. E. Richart, respectively. Other members of the committee were: F. R. McMillan, R. L. Bertin, W. S. Thomson, P. H. Bates, R. D. Snodgrass, W. F. Zabriskie and Inge Lyse. Since the death of Prof. Slater on Oct. 5, 1931, Prof. Richart has been chairman and Prof. Lyse has been in charge of the tests at Lehigh. Assistance on the test program has been furnished by a large technical corps, of whom G. C. Staehle of the staff of the Portland Cement Association and C. L. Kreidler of Lehigh University are joint authors of progress reports that have been published on the tests.

The investigation has been sponsored by the American Concrete Institute and was made possible through the raising of a test fund of more than $25,000 in cash and materials donations among the institute membership, in addition to the contribution of testing facilities and the services of those in charge at the two laboratories for the two-year period, which, it is estimated, is equivalent to about $15,000.

Assuming Responsibility for Structural Welding

Engineer handling his first welded building outlines precautions and procedure that he found useful and efficient

By E. E. Seelye
*Consulting Engineer, New York, N. Y.**

Another Title for this article might be "What Every Engineer Should Know About Structural Welding." For as structures required to be welded come into offices without previous welding experience a need will exist for knowledge on administrative and supervisory matters, if not upon actual weld design. On the work described in this article the design was made by a specialist in structural welding. The structural engineer, on the other hand, as the representative of the owner, set up certain requirements of procedure and inspection. As is universal, the safety of the job was his responsibility. The account of his experiences should elicit wide interest.

—Editor.

What should the structural engineer know and do when he takes responsibility for a welded frame? Much of the published literature on welded structures has dealt with structures owned by electrical interests and described by engineers frankly in the employ of these interests. While these engineers have been men of high standing, the information in their articles has nevertheless not been entirely free from the suspicion of optimism. The independent engineer has asked himself numerous questions about structural welding. "How reliable is it? Supposing many welds have cracked during construction of these buildings, would I have heard of it? How practical is it? Does it really save money over riveted structures, or are figures given on economy not impartially presented? What special knowledge is required for the design of welded details, and are the complications very great? Can the quality of the welders be controlled? What training and knowledge does a welding inspector require?"

An opportunity to meet and answer these questions at first hand came to the writer when he received instructions to make a Yale University dormitory quadrangle at Elm and College Sts., New Haven, an all-welded structure. This structure, as shown in Fig. 1, presented a wide variety of complicated framing, bringing into play almost every conceivable problem in designing welded connections, with the exception of extremely heavy connections, and even these may be said to have been represented in some of the offset column supports. The large number of members involved, with no duplication, rendered it a very good test as to the uniformity and reliability of the welding. A total of 940 tons of steel was involved.

The shop drawings were based on a group of typical welded details, illustrated in Fig. 2. In a riveted job, erection plans furnish adequate field information, since open holes indicate rivets. In welding, however, additional drawings are necessary to show length, size and location of field welds; and since the working drawings of the members are too voluminous for field use, these typical details were lettered and numbered and the erection plans given corresponding marks at each connection. These typical details also enable a contractor to estimate approxi-

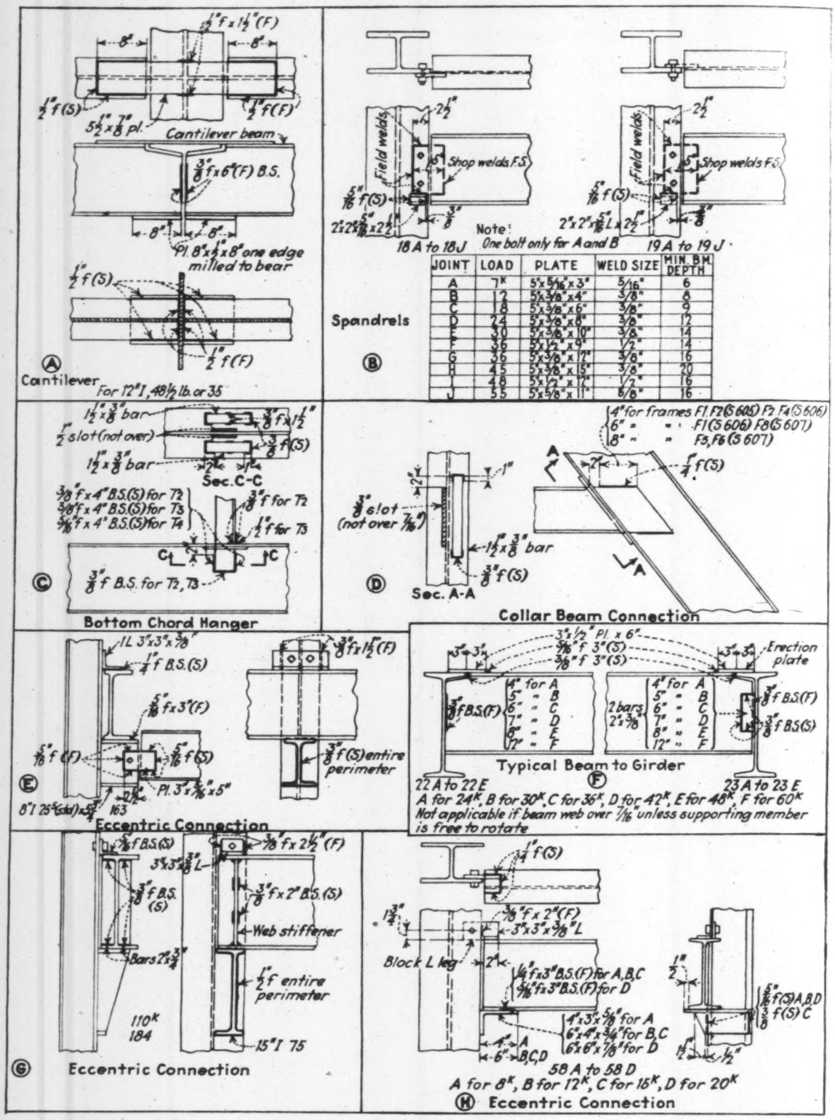
Fig. 1—Welded quadrangle dormitory at Yale University involved such an irregular framing layout that all columns and most of the beams and roof girders required individual shop drawings. By virtue of this complication it offered a good proving ground for determining the uniformity and reliability of welding

mately the amount of welding required.

While the design of the welded details and the detailed inspection were to be in charge of a collaborating expert, the writer undertook full responsibilty for the safety of the work for his clients, the architects. To do this he conceived it necessary to follow through with the following precautions that are listed here as the points deemed necessary to protect any welded job.

Precautions on a welded job

1. Check design of typical weld details:
   (*a*) To see that sufficient weld has been provided for both direct and eccentric stress.
   (*b*) For flexibility to eliminate dangerous stresses on welds due to negative moment.
   (*c*) For ready access for field welders.
2. Check shop drawings to insure:
   (*a*) That the proper typical weld details are called for on the erection plans to provide adequately for the load and eccentricity requirements of each joint.
   (*b*) That the beam and column shop drawings show the shop-welding in accordance with the typical weld detail called for on the erection plan.
   (*c*) That proper sizes of members are used.
3. Control of contractor and welders:
   (*a*) Limit the list of bidders on the steel contract to concerns whose previous experience in welding indicates that they are properly qualified.
   (*b*) Provide in the specifications that the qualifications of all welding operators should be passed on by the shop or field inspectors, both of whom should be employed by the engineer.
   (*c*) Select inspectors who are qualified by having had responsible charge of previous work.
   (*d*) Employ a supervisory inspection system under which the designing engineers go out to the job and check up the more complicated welds. This makes certain that the system of safeguards is actually functioning.


Cantilever beam
Pl. 8"x1/2"x8" one edge milled to bear
Ⓐ Cantilever For 12" I, 48½ lb. or 35
Field welds
Shop welds F.S.
Note: One bolt only for A and B
18 A to 18 J
19 A to 19 J
Spandrels
Ⓑ
Sec. C-C
Ⓒ Bottom Chord Hanger
4" for frames F1, F2 (S 605) F3, F4 (S 606)
6" " " F1 (S 606) F8 (S 607)
8" " " F5, F6 (S 607)
Sec. A-A
Ⓓ Collar Beam Connection
Ⓔ Eccentric Connection
Erection plate
Typical Beam to Girder
Ⓕ
22 A to 22 E
23 A to 23 E
A for 24^K, B for 30^K, C for 36^K, D for 42^K, E for 48^K, F for 60^K
Not applicable if beam web over 7/16" unless supporting member is free to rotate
Web stiffener
Ⓖ Eccentric Connection
Block L leg
58 A to 58 D
A for 8^K, B for 12^K, C for 16^K, D for 20^K
Ⓗ Eccentric Connection

JOINT	LOAD	PLATE	WELD SIZE	MIN. BM. DEPTH
A	7^K	5"x5/16"x3"	5/16"	6
B	12	5"x3/8"x4"	3/8"	8
C	18	5"x3/8"x6"	3/8"	9
D	24	5"x3/8"x8"	3/8"	12
E	30	5"x3/8"x10"	3/8"	14
F	36	5"x1/2"x9"	1/2"	14
G	36	5"x3/8"x12"	3/8"	16
H	45	5"x3/8"x15"	3/8"	20
I	48	5"x1/2"x12"	1/2"	16
J	55	5"x5/8"x11"	5/8"	16

Fig. 2—Typical weld details used on Yale dormitory. These "key" connections were called for by letter designations on the framing plans. Thus, if, a 200-kip H-type connection was called for, the detail in the lower right-hand corner would be used (6x6x7/8-in. seat angle and 5/16-in. fillet welds).

Weld design

The design of the welds presents several points of interest. Particular care was taken to obtain flexibility for the end connections of beams and girders. Here welding is in a different category from reinforced concrete and riveted steel. In riveted steel the secondary stress due to beam deflection is almost never dangerous to the strength of the load-carrying rivets. The reason for this is obvious. Almost all connections are made with angles that are flexible, and the length of the rivet permits considerable elongation before rupture. Even a perceptible shearing distortion of a rivet group leaves a very large proportion of its strength intact.

Concrete, on the other hand, is generally designed for full continuity, but if not and a negative moment crack appears, the strength of the beam, while undoubtedly impaired in shear, is generally not dangerously so. In the case of two beams coming into a girder opposite each other a web fillet weld is particularly vulnerable (Fig. 3). If it cracks at the top due to negative movement, tension may start a fissure causing total failure of the connection.

Required flexibility of the welded connections was obtained in several ways. In the case of another framing connection (Fig. 3) the warping of the angles will provide ample flexibility. As framing angle connections are not as economical as those shown in Fig. 2F and not suitable for the case shown in Fig. 2B, reliance was placed on the use of welds that were stronger than the beam webs and not more than three-quarters of the beam depths in height, so that the web might be expected to distort by rotary strain in the plane of the web and thus permit the beam end to take its natural slope under the load without overstraining the weld. This limitation is based largely on tests and experience, and further tests may result in strengthening or lessening this requirement.

Limits placed on design

In the present state of the writer's knowledge, the following additional precautions were imposed on the designer:

1. Butt-tension welds were avoided.
2. All major loads were carried on at least two separate and distinct welds.
3. Heavy reactions from offset columns were in general carried by direct bearing.

4. Division of a load between a shop-welded seat and a field web weld was discouraged (Fig. 3).

Butt-tension welds were avoided on the theory that incomplete fusion is more serious in direct tension than in shear. Also there is a question of whether stresses due to cooling may not endanger this type of joint. However, welds were used in tension in eccentric connections, as in Fig. 2E.

It seems safer to distribute the load of a reaction over more than one weld on the same principle that we prefer to depend on a group of small rivets rather than on one large rivet. However much confidence we may have in the strength of a weld, sooner or later we are sure to get a bad one, and if we have distributed our load over more than one weld, we shall be glad of it.

Fig. 2D shows how the collar-beam-truss lower chord was connected by slotting the I-beam rafter by a gas cut, giving shear instead of a butt-tension connection. The loss in flange metal is replaced by reinforcement. A butt-tension connection would have been particularly questionable because as the collar beam took a flexural load it would have induced dangerous secondary stresses in the connection.

Fig. 4 shows an unusual detail made possible by welding. Beams B-2 and B-3 were too close to admit welding between, and the loads were too great to handle on shallow one-sided connections. The plates were welded to the ends of B-3, and square holes were made in B-1 and B-4 in the shop. B-1, B-2 and B-4 were erected and welded with B-3 loose between B-1 and B-4 and far enough away from B-2 to permit welding the latter. B-3 was then pushed over into position and end plates were welded to the supporting girders through the square holes in the webs of the latter.

Inspection

The inspector of welding should be qualified by experience. He should be able to pass a welder's test. Actually, what can he tell about a weld after it is made? He knows that:

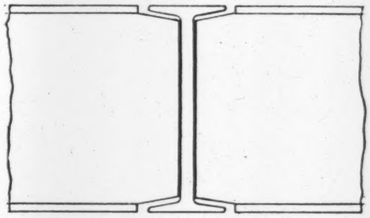
1. Uniform ripples are an indication of good welding, representing the increment deposited from the electrode at its pauses as it is moved along the weld.

2. The contact of the edge of the weld with the metal should show fusion rather than a lap or fissure.

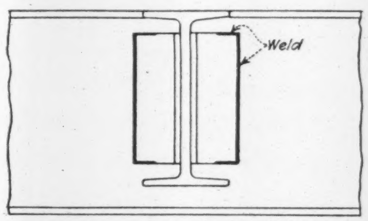
3. The surface should not have a burned-out appearance.

4. The voltage at the arc should be about 18, and the amperage about 190 with a $\frac{3}{16}$-in. wire. This means a somewhat higher voltage, say of 20-23 volts at the machine. The inspector should watch the machine to see that these requirements are being met.

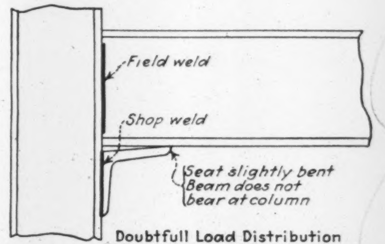
The specifications required direct-current arc-welding, with electrodes limited to $\frac{3}{16}$ in. in diameter, except for special purposes as permitted by the inspector. The wire was of pure mild steel. Materials and workmanship were required to conform to the code for fusion welding and gas cutting in building construction as published by the American Welding Society. Welding operators, materials, welding equipment and workmanship were made subject to the approval of the engineers and their inspector. The welding was done with 200-amp. d.c. welding generators.



Dangerous Continuity and Flexibility



Good Connection for Flexibility



Doubtfull Load Distribution Between Shop and Field Weld

Fig. 3—Two types of weld connections whose use was discouraged, and one in which good flexibility is secured by using connection angles.

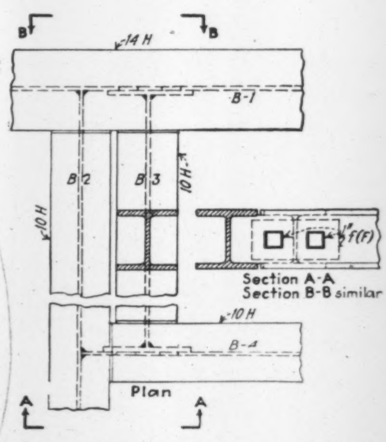


Fig. 4—A special heavy-duty detail in which additional welding was provided by cutting square holes in the webs of connecting beams.

In work not directly supervised by the same engineers responsible for the design and details, closer specific limitations on these matters would be advisable, but the plan as outlined worked well in this operation.

Conclusions

On this particular job the welded cost was about 10 per cent less than the riveted bids. However, the issue was clouded because the welded bids contemplated open-shop erection, while the riveted bids were based on closed-shop erection. Also the engineering cost was perhaps three or four dollars per ton higher for the welded design.

As to reliability, no cracks occurred in any of the 25,000-odd welds in this structure in so far as the writer is aware. Certainly none occurred after the load was on because it would show up in cracks in fireproofing and plaster.

With the care taken in design and particular care taken in the field, the writer feels that an adequate degree of safety in construction has been obtained in the art of structural welding to warrant its admission into the society of approved structural materials. At the present time it is not nearly so foolproof either in design or execution as riveted steel, and like reinforced concrete it will probably always require special expert attention.

Welding offers a great convenience for field changes. Field changes in riveted steel have always presented a disproportionate cost to original fabrication. The field change may be made by welding very economically once the equipment is on the job.

The clean-cut appearance of welded steelwork, as shown in Fig. 1, will appeal to the architects, to whom it will be evident that the ordinary gussets and connecting angles of riveted steel would add to the problem of architectural clearances.

The architect of this building was John Russell Pope. Marc Eidlitz & Son, Inc., was the general contractor; the Pittsburgh Bridge & Iron Works was the steel contractor. Gilbert D. Fish, consulting engineer, Westinghouse Electric & Manufacturing Co., was the collaborating expert in welding, and the work was designed and inspected under the immediate supervision of H. C. Lamb, of the writer's organization.

* * *

Irrigation in India

According to the triennial report on irrigation by the Department of Industries and Labor, government of India, irrigation for the year 1929-1930 covered about 31,648,000 acres, or 12.7 per cent of the total area sown for crops. The irrigated area was about 3,800,000 acres more than in 1927 and is included in twelve provinces.

Time Studies of Concrete Paving Bring Large Savings

Analysis of 1929 and 1930 paving operations result in improvement each year in utilizing available working time and increasing pavement production in Pennsylvania road work

By P. M. Tebbs

Assistant Chief Engineer, Pennsylvania Highway Department, Harrisburg, Pa.

TIME-LOSS studies in highway construction have received less credit than their precision and value have justified. In a measure their very minuteness has been the deterrent. Contractors overlooked the magnitude of the cumulative aggregates in their amusement at holding a stopwatch on steam shovels and trucks and the counting of split seconds of time lost. Such microscopic practices had not come within their purview as means of wrestling with a mountainside cut or keeping in step a train of hauling and paving operations extending over several miles of roadwork in progress. It took time for the evidence to be absorbed, and part of the delay was due to its ineffective presentation. Effective presentation was the task undertaken as paramount in the studies described in the article that follows. Its success has been striking. In part this is perhaps due to the fact that conditions and competition have compelled greater attention to be given to refinements of management, but persistent presentation of time lost and performance figures counted heavily. As an example of constructive lost-time analysis to increase road-building output, the article that follows deserves close study. —EDITOR.

PRIOR to 1929 no definite or comprehensive study had been made by the Pennsylvania highway department of rates of progress in concrete paving. From time to time data had been secured and analyzed, but the attitude of the department had always been that as long as the contractors completed their projects within the time allowance, the rate of progress was purely the contractor's responsibility, and any suggestion from the department might be considered as usurpation of the contractor's prerogatives.

In 1929 a detailed record was kept by the department inspectors of the available paving time, time lost, actual paving time and rate of progress per paving hour. In establishing the available time, the time in which the contractor could not work on account of rain, wet subgrade and other similar natural conditions over which he had no control was not considered as available and was deducted accordingly. The available time was the total time the contractor should have worked, and the lost time is that in which he did not work due to faults and deficiencies in his organization and management.

Results of 1929 study

The results of the time studies made in 1929 are given in Table I. An analysis of results shows the true reason for the ills, woes and difficulties of the paving-construction industry in Pennsylvania. No industry can be in a healthy condition that operates 76.4 per cent of its available time and when in operation produces at only 60 per cent of maximum capacity. This 60 per cent is predicated on a modern paving mixer turning out 40 complete batches per hour, while the production in 1929 was only 24 batches per hour. Mixing time in Pennsylvania is 1¼ min. after all materials have entered the mixing drum. Maximum paving efficiency allows ¼ min. for loading and discharging.

Study and research were continued during the winter months, with special attention paid to the proper unit of comparison between the various jobs; the time of mixing cycle and the method of actual operation of the mixer, including the mixing that would result in the smallest possible amount of lapsed time.

In establishing the unit of comparison the number of batches per hour proved the best method. If length in feet per hour were used as the unit, the comparison between the different jobs would be affected by the size of the paving mixer and the different widths and depths of pavement. If square yards per hour were used, the comparison would be affected by the size of the paving mixer and the different depths of pavements. The number of batches per hour is not affected by these distinctions.

The mixing cycle of 1½ min. per batch for maximum efficiency was based upon continuous operation of the mixer, including the time of moving on the subgrade when the pouring of the pit was completed. This meant that a section of subgrade would have to be ready at all times to receive a batch of concrete, and a truck or other batch-carrying equipment would have to be available at all times for charging the skip. The responsibility for having subgrade and truck available was purely a question of proper and coordinated management, but it became apparent during the study that by changing slightly the requirements for testing the subgrade before the concrete was deposited that efficiency of operation could be increased materially. It became very apparent that the mixer operator was a most important factor in efficiency.

To maintain the cycle of 1½ min., it is absolutely necessary to open the discharge immediately when the bell rings and the locking device releases. A delay of a second in this operation will destroy the maximum-efficiency schedule. Also immediately upon release of the discharge, the skip must be raised so that the batch will start into the drum as the last portion of the former batch leaves the drum. While the mixing time is 1¼ min., it requires about 5 sec. to empty the skip after it is in upright position. This 5 sec. must be considered in the mixing cycle and is a most important factor.

Automatic paving mixers, which take the control out of the operator's hands to a very considerable extent, have been most vital in increasing progress and efficiency, but it is still most essential

TABLE I — TIME LOSSES AND OUTPUT RECORDS ON CONCRETE PAVING IN 1929 IN PENNSYLVANIA

	Miles Paved, 1929	Sq.Yd. Paved, 1929	Working Hours and Output				
			Hours Possible	Hours Lost	Actual Hours	Per Cent Time Lost	Sq.Yd. Laid per Working Hour
Div. 1	102.10	1,068,836.41	12,121.37	2,177.42	9,943.95	18.0	107.5
Div. 2	30.75	314,328.00	3,665.00	544.915	3,120.085	14.86	100.74
Div. 3	59.05	657,263.00	7,653.25	1,437.00	6,216.25	18.8	106.00
Div. 4	53.10	572,565.00	7,320.00	1,777.00	5,543.00	24.0	103.00
Div. 5	72.34	824,070.00	14,144.00	3,645.50	10,498.50	25.78	78.49
Div. 6	59.64	641,979.00	9,862.00	3,454.00	6,408.00	35.0	100.18
Div. 7	34.95	389,068.00	3,839.00	455.00	3,384.00	12.0	115.00
Div. 8	42.00	491,852.20	6,604.25	1,904.25	4,700.00	28.8	104.70
Total	454.93	4,959,961.61	65,208.87	15,393.08	49.813.79	23.6	99.57

DISTRIBUTION OF TIME LOSSES

Transportation		Water Condition		Subgrade and Forms		Equipment Breakdowns		Lack of Materials		All Other Causes	
Hours	Per Cent	Hours	Per Cent	Hours	Per Cent	Hours	Per Cent	Hours	Per Cent	Hours	Per Cent
336.27	2.8	110.35	0.8	458.42	3.8	483.19	4.0	481.55	4.0	307.64	2.5
11.00	0.30	11.83	30.32	116.58	33.18	117.41	63.20	87.00	2.37	201.083	5.49
89.00	1.2	21.75	0.3	139.50	1.8	276.50	3.6	237.75	3.1	672.50	8.2
290.00	4.0	79.0	1.0	489.0	7.0	198.0	3.0	325.0	4.0	396.0	5.0
271.00	1.92	172.25	1.22	1,080.75	7.64	516.50	3.65	421.50	2.98	1,183.50	8.37
201.00	2.0	154.00	2.0	815.0	8.0	366.00	4.0	880.00	9.0	1,038.0	10.0
132.00	4.0	36.0	4.0	124.0	3.0	92.0	2.0	35.00	1.0	36.0	1.0
370.00	5.6	80.75	5.6	429.25	1.2	252.25	3.8	140.25	2.1	631.75	9.6
1,700.27	2.61	665.93	1.02	3,652.50	5.60	2,301.86	3.53	2,608.05	4.00	4,466.47	6.85
	11.05		4.32		23.72		14.95		16.94		20.02

—Condensed from a paper read at the annual convention of the Association of Highway Officials of the North Atlantic States.

TABLE III — COMPARATIVE PAVING EFFICIENCY IN 1929 AND 1930

Year	Miles Paved	Sq.Yd. Possible	Sq.Yd. Lost	Actual, Sq.Yd.	Per Cent of Time Utilized	Batches per Working Hour	Per Cent Efficiency	True Efficiency, Average
1930	796.10	84,615	15,357	69,256	81.85	29.36	73.91	60.50
1929	454.93	65,209	15,395	49,814	76.40	24.00	60.00	45.84
Increase in efficiency in 1930 over 1929					7.13		23.18	31.98

to have an operator who is intensely interested in the progress of the work and who places loyalty to his employer above his interest in the whims, fancies and desires of the men working on the job.

The old method of the department in checking the subgrade before placing the concrete provided that the entire length of the pit had to be checked with a subgrade tested and the pit corrected and rechecked, the process being continued until the entire area was satisfactory. This resulted in a continuous loss of time if a portion of the pit farthest from the mixer was correct and high spots had to be removed from the area nearest the mixer. To reduce this obvious loss of time, the department adopted the policy of permitting concrete to be deposited on the grade after one-half the pit was checked and corrected, with the understanding that the subgrade tester was to remain on the forms at the point to which the subgrade was correct and that no concrete was to be placed on the side of the subgrade tester on which the subgrade was not correct. The subgrade tester was then to be advanced as the grade was further checked and corrected.

With the mixing cycle established, the important problem remained to eliminate the time loss when the mixer moved, and the following method was decided upon as the most efficient and economical: (1) discharge bucket and load drum, keeping skip in air; (2) dump concrete in pit; (3) move to new position; (4) lower skip to ground; (5) fill skip from batch truck; and (6) discharge concrete into bucket and load drum. This method of operating permits continuous mixing while the paver is moving to a new position. Dumping the concrete in the pit before moving permits the move to be made with an empty bucket, so that if the subgrade, which is an unknown factor, is not corrected to receive concrete in the new pit, the next batch can be placed in the bucket and the mixing cycle continued. This method, combined with preparing one-half of the pit at a time, was assumed to eliminate all lost motion on a well-organized job.

Results of 1930 study

At the start of the 1930 season quite a number of contractors were eager to adopt these suggested methods, and on their jobs the progress increased immediately. In many cases the production was doubled over that of previous years. Comparative records were forwarded weekly to the central office. This information was tabulated and sent out weekly to contractors and to material, equipment and surety companies interested in highway construction.

At the end of this season the records of all the individual jobs were again summarized, as shown in Table II. The per cent of lost time varied from 10.24 to 24.05, averaging 18.15; the number of batches varied from 24.31 to 33.66 per hour, averaging 29.56; and the square yards of pavement laid per working hour varied from 104.7 to 136.87, averaging 127.08. Table III is a comparison of the 1929 and 1930 results.

This tabulation is based upon the total number of jobs handled by each contractor. In some cases the record of the individual jobs shows a higher rating than the final average would indicate. In 1920, 2 or 3 miles per year was considered a season's work of placing concrete pavement. In 1930 several contractors paved more than 15 miles with one paving outfit, and one contractor built seven jobs with two outfits. From the standpoint of the true efficiency average, 79 contracts were better than the state average and 83 were below that average. If the 79 above the average had constructed more than 10 miles each, the remaining 83 would not have been required to complete the large 1930 program. With the much higher average that would have obtained under these conditions, the roads could have been completed that much sooner with all the resultant advantages.

That the contentions of the department were fundamentally sound and the suggestions for correcting the conditions meritorious is proved by comparison of the 1929 and 1930 reports. The increase from 76.4 to 81.85 per cent of the total available time, or a 7.13 per cent increase, is fair, but it leaves a large field for further study. The increase in the number of batches per hour from 24 to 29.56, an increase of 23.18 per cent, is very gratifying. The true efficiency is determined by multiplying the time efficiency by the operating efficiency. The 1930 mark of 60.50 per cent is a 32 per cent increase over the 1929 work of 45.85 per cent.

A comparison of the reasons for lost time for the two years is most illuminating. With 2.95 per cent of the total time lost in transportation in 1930 (as compared with 2.61 per cent in 1929) and 3.61 per cent of total time lost on breakdowns in 1930 (3.52 per cent in 1929), the fact is deduced that increasing the time and operating efficiency tends toward more breakdowns of mixing and hauling equipment. To overcome this, further studies should be undertaken by the individual contractor, contractor's associations and equipment manufacturers to ascertain the principal breakdowns, so that corrections may be made in future designs, and repair parts of frequent breakdowns may be stocked for existing machinery.

The decrease from the loss of 4 per cent of total working time for lack of materials in 1929 to 1.72 per cent in 1930 shows what can be done where an organized effort is made to correct a very specific condition. The fear of shortage of materials in 1930 caused every contractor, material producer, transportation executive, surety agent, and highway engineer to exert every possible effort to guard against an anticipated shortage. The cooperative committee that was organized from all representative branches of the industry also rendered invaluable service.

The decrease from 5.60 per cent in 1929 to 3.94 per cent in 1930 of losses due to subgrade and forms, while an improvement, is not very satisfactory.

TABLE II — TIME LOSSES AND OUTPUT RECORDS ON CONCRETE PAVING IN 1930 IN PENNSYLVANIA

	Miles Paved, 1930	Sq.Yd. Paved, 1930	Working Hours and Output: Hours Possible	Hours Lost	Actual Hours	Per Cent Time Lost	Batches per Working Hour	Sq.Yd. Laid per Working Hour
Div. 1......	144.47	1,576,749	13,701.90	2,181.73	11,520.17	15.92	33.66	136.87
Div. 2......	113.03	1,213,908	10,945.39	1,847.16	9,098.23	16.88	31.00	133.42
Div. 3......	66.51	696,429	6,710.54	1,221.09	5,489.45	18.20	30.97	127.10
Div. 4......	129.47	1,458,014	13,173.65	1,723.95	11,449.70	13.09	29.21	127.34
Div. 5......	144.29	1,535,996	15,172.87	3,119.05	12,053.82	20.56	29.27	127.80
Div. 6......	95.70	1,042,230	10,314.28	2,322.50	7,991.78	22.52	30.16	130.41
Div. 7......	39.77	476,409	4,112.42	420.93	3,691.49	10.24	28.04	128.99
Div. 8......	62.86	833,704	10,483.25	2,521.00	7,962.25	24.05	24.31	104.70
Total.....	796.10	8,833,439	84,614.30	15,357.41	69,256.89	18.15	29.56	127.08

DISTRIBUTION OF TIME LOSSES

Transportation		Water Condition		Subgrade and Forms		Equipment Breakdowns		Lack of Materials		All Other Causes	
Hours	Per Cent	Hours	Per Cent	Hours	Per Cent	Hours	Per Cent	Hours	Per Cent	Hours	Per Cent
426.60	3.11	205.66	1.50	378.14	2.76	484.32	3.54	153.79	1.12	533.22	3.89
298.68	2.73	143.93	1.32	402.36	3.68	349.66	3.19	260.25	2.38	392.28	3.58
284.25	4.24	97.13	1.45	266.97	3.98	212.50	3.16	80.32	1.20	279.92	4.17
381.62	2.90	134.23	1.02	308.62	2.34	287.25	2.18	118.82	0.90	493.41	6.75
421.70	2.79	227.01	1.50	715.97	4.73	519.59	3.43	265.50	1.75	969.18	6.36
245.10	2.38	145.18	1.41	568.40	5.51	494.83	4.80	345.50	3.35	523.49	5.07
82.21	2.00	27.21	0.66	50.55	1.23	142.94	3.48	53.24	1.29	64.78	1.58
351.75	3.36	95.00	0.91	640.75	6.11	567.50	5.41	178.75	1.70	687.25	6.56
2,491.91	2.95	1,075.35	1.27	3,331.76	3.94	3,058.69	3.61	1,456.17	1.72	3,943.53	4.66
	16.23		7.00		21.70		19.92		9.48		25.67

With the almost perfect weather conditions of 1930, the loss of time from this source should have been reduced to the absolute minimum instead of showing only a slight improvement. This again proves most conclusively that few contractors are capable of organizing to work every day; and when weather permits continuous operation, they are not able to keep ahead of paving with a satisfactory amount of subgrade and forms. This was noted in numerous specific cases on inspection trips of department representatives.

The greater loss of time in 1930 on account of water conditions was to be expected as a result of the drought. The figure of 1.27 per cent of total time lost in 1930, as compared to 1.02 per cent in 1929, is not very great and would have been much more had not the contractors exerted great effort to combat a very obvious condition. The decrease in loss of time for miscellaneous causes is a substantial improvement in 1930 over 1929, and this can be bettered to a very considerable extent.

The completed figures of 1931 are not as yet available, but a summary of those already compiled shows a time efficiency of 82.6 per cent, with an operation efficiency of 78 per cent, or a true efficiency average of 64.4 per cent, which proves conclusively that steady progress and improvement are being maintained and that the efforts of the department are continuing to bear fruit to the advantage of every party comprising the industry.

Letters to the Editor

Water Resources and Tax Dollars

Sir—Reduction of the government appropriation for the study of water resources would be a misfortune. Some 30 years ago a newspaper writer of highest standing phoned to me that he had just prepared an editorial condemning the proposed action of the California legislature in matching a $40,000 government allotment for stream-gaging work in this state. "Having myself been a state official," he said, "I know that the state engineer has already completed a study of the state's water resources and that this proposed duplication of data would be a perfectly useless expenditure." In reply I said: "All that the state engineer could do in the few years covered by his observations was to record a few pertinent facts relating to the behavior of California's principal rivers. His observations fell into a period devoid of extremes. There was no period of great drought. There was no season of minimum runoff such as that of 1863-64, nor yet one of maximum rainfall conditions with phenomenal floods such as that of 1861-62. Nature does not accommodate the engineer by producing extremes of climate just when he is ready to use the resulting volumes of streamflow as the basis for water-supply or for flood-control projects. Stream measurements must be continuous. Moreover, they should be greatly extended so that in the course of time the engineer will know what amount of water production can be counted on per square mile of area in all parts of the country. Water is this nation's most important natural resource. In many regions it will ultimately be put to use to the limit of its availability. This state should be grateful to the government for its offer of cooperation." The reply from the editorial writer was gratifying. "Thanks for your explanation. I have torn up my editorial and shall write another favoring the appropriation."

THE DANCE OF THE DOLLAR

All Within a Year

The tax-eater gets $100	$100
He gives it to the grocer	100
The grocer pays rent with it	100
The landlord buys clothing	100
The clothier pays a salesman	100
The salesman buys a radio	100
The radio dealer pays the florist	100
The florist pays a gardener	100
The gardener makes final payment on furniture	100
The furniture dealer pays the dentist	100
The dentist pays a nurse	100
The nurse gives the building and loan association	100
The association gives Smith a dividend	100
Smith pays his lawyer	100
The lawyer pays the title insurance company	100
The company buys stationery	100
The stationer puts in a new case	100
The showcase builder buys lumber	100
The lumber dealer advertises	100
The newspaper pays a distributor	100
The distributor pays on his auto	100
The auto dealer gives a banquet	100
The hotel pays the baker	100
The baker pays the miller	100
The miller pays the farmer	100
The farmer buys a plow	100
The implement dealer hires an architect	100
The architect buys his wife a dress	100
The drygoods dealer pays his light bill	100
The light company sends out printed propaganda	100
The printer puts in a new press and sends the $100 East, where it still keeps on traveling	
Total business in a year	$3,000

The value of the records of the water resources branch of the U. S. Geological Survey cannot be too strongly stressed. Moreover, their publication is of prime importance. By printing they are made universally available. If preserved in local offices and at Washington without being printed the inconvenience and expense to individuals and communities that need the data would be unbearable. Printing of valuable data is always in the line of efficiency and economy.

And now just one word more. I sent a little memorandum, "The Dance of the Dollar," to a local paper a few days ago. I do not expect it to be published. No one seems to have courage to tell the public that in hard times the government should not cut down expenditures and discharge employees, but should rather increase activities, thereby maintaining greater numbers in the class of non-producing consumers and by circulating money make conditions better for the fewer left for work in the industries and on the farm. It may set some to thinking along correct lines, so I am sending it to you.

If this illustration were true it would take only a little more than a 3 per cent tax on this amount of business, all resulting from what may be a useless government expenditure of $100, to start another $100 on its rounds next year. The situation is not so favorable, however, because as the money passes from hand to hand there is shrinkage. Nevertheless taxes make business. Unwise government economy makes unemployment. Reform the taxation system so that none will contribute to the cost of government except those able to pay.

C. E. GRUNSKY.

San Francisco, Calif.,
April 28, 1932.

Brick Keeps Surface on Non-Rigid Base

Sir—The article on the brick-on-metal-base experimental road (*ENR*, May 12, 1932, p. 694) contains the following statement: "In summing up, it may be said from the results of this experiment that a bituminous-filled brick surface must be constructed on a rigid base."

It is realized that this conclusion is quoted verbatim from the report. An edict that brick pavements must not be constructed on other than rigid bases is entirely too broad and all-inclusive. The terms rigid and flexible, as applied to pavement structures, are relative. What are customarily known as flexible-base courses do not approach the degree of flexibility and absence of mass that obtained in the case of the thin metal sheets used in the Illinois experiment, which resulted in failure. It should also be remembered that in many other localities the climatic, subsoil and traffic conditions that existed in the Illinois test are not present.

Many brick pavements that have given long years of successful service on so-called flexible bases such as macadam, Florida lime rock, compacted granulated slag, gravel, and even natural sandy subgrades without intermediate base, prove that this type of base course is economical and practical if the conditions are favorable. To condemn what is commonly termed non-rigid base construction in general "from the results of this experiment" is misleading from an engineering standpoint and not justified by recorded experience.

G. F. SCHLESINGER,
Chief Engineer and Managing Director,
National Paving Brick Association.

Washington, D. C.,
May 18, 1932.

NEWS OF THE WEEK

Loan for New Construction Made to Pennsylvania Railroad

The Interstate Commerce Commission has approved a loan of $27,500,000 from the Reconstruction Finance Corporation to the Pennsylvania Railroad for the continuation of its electrification and terminal improvement program. The Pennsylvania Railroad originally applied for a loan of $55,000,000 but subsequently cut the request to half that amount, agreeing to raise the remainder by the sale of its securities. By this sale and by the loan the railroad will obtain the major part of the $68,000,000 required to carry forward its program according to schedule during the year 1932.

The projected expenditures are as follows: $47,000,000 for electrification work between New York and Washington, $2,000,000 for reconstruction of the railroad's passenger terminal facilities in Newark, N. J., $9,800,000 for continuing the reconstruction of its freight and passenger terminal facilities at Philadelphia, $1,500,000 for its terminal improvements at Baltimore, and $7,800,000 for miscellaneous expenditures.

Paving Contracts Continue Despite Taxpayers' Suit

Work on the six paving contracts, cancellation of which was asked in a taxpayers' suit, filed recently in St. Paul, Minn. (*ENR*, May 19, p. 742), is being continued in order to maintain the workers in employment. When the contractors' monthly estimates were submitted, an agreement was reached to allow them 80 per cent instead of 85 per cent of their estimate, pending the court's action.

Gov. Olson has appointed a committee consisting of William N. Carey, chief engineer, St. Paul; John Wilson, chief engineer, Duluth, and Charles W. Armstrong, city engineer, Rochester, Minn. The city of Minneapolis instructed N. W. Elsberg, city engineer, not to serve on this committee.

Ohio Office Building Frame Not Damaged by Explosion

Official investigation of damage to the Ohio state office building at Columbus by the explosion of April 14 resulted in the finding that the structural frame of the building was not damaged in any way, according to Kenneth H. Osborn, of the investigating committee. The other members of the committee were Lester Redding, Mansfield, member of the Ohio board of registration for architects; Don Hoskins, Franklin County prosecutor, and F. G. Henry, state fire marshal.

As already reported by Prof. Clyde T. Morris (*ENR*, April 21, p. 597) the sub-basement was concluded to be the seat of the explosion. There was no evidence that a high explosive was involved, and the opinion was reached that accidental ignition of an accumulation of gas in the sub-basement caused the explosion.

The concrete slabs of the basement floor, ground floor and first floor were destroyed, but columns and beams were unaffected. The concrete walls of the sub-basement were somewhat damaged. On all floors of the building there was considerable damage to tile partitions and to steel partitions. The exterior walls in the lower section were much damaged, especially the west wall, a large part of which will have to be rebuilt. In the upper part of the building the walls were little damaged except for a few sash and some lights of glass. Damage to marble, bronze and ornamental plaster work made the money loss heavy.

Bids Called for Power for Los Angeles Aqueduct Work

The Metropolitan Water District of Southern California, May 18, called for bids for furnishing electric power for the construction of the proposed Colorado River aqueduct. Actual construction of the aqueduct is held up pending validation of the proposed bond issue of $220,000,000, but the district is laying the groundwork for an early start of construction.

Ultimately, power for pumping will be supplied from Hoover Dam, but at present the power needed for construction operations along the 226-mile aqueduct is not available.

President Hoover Expresses Disapproval of Public Works Construction Program

In letter to the president of the American Society of Civil Engineers President Hoover expresses disapproval of the program for business revival put forward by the society and outlines his own plan for government aid to industry

DISAPPROVAL of what he believes to be the fundamental principles of the proposal for business revival through resumption of public construction put forward by the American Society of Civil Engineers (*ENR*, May 19, p. 732) is expressed by President Hoover in a letter to Herbert S. Crocker, president of the society. (The letter, dated May 21, as released to the newspapers was addressed to Richard S. Parker.) Extracts from the letter follow:

"I am in receipt of your kind letter of May 19, and I have also the presentation of the subcommittee of the society suggesting that the depression can be broken by a large issue of federal government bonds to finance a new program of huge expansion of 'public works' construction, in addition to the already large programs now provided for in the current budgets.

"The back of the depression cannot be broken by any single government undertaking. That can only be done with the cooperation of business, banking, industry and agriculture in conjunction with the government.

"The aid the government may give includes:

(a) The quick, honest balancing of the federal budget through drastic reduction of less necessary expenses and the minimum increase in taxes.

(b) The avoidance of issue of further Treasury securities as the very keystone of national and international confidence upon which all employment rests.

(c) The continuation of the work of the Reconstruction Corporation which has overcome the financial strain on thousands of small banks, releasing credit to their communities; the strengthening of building and loan associations, the furnishing of credit to agriculture, the protection of trustee institutions and the support of financial stability of the railways.

(d) The expansion of credit by the Federal Reserve banks.

(e) The organized translation of these credits into actualities for business and public bodies.

(f) Unceasing effort at sound strengthening of the foundations of agriculture.

(g) The continuation of such public works in aid to unemployment as do not place a strain on the taxpayer and do not necessitate government borrowing.

(h) Continuation of national, community and individual efforts in relief of distress.

(i) The introduction of the five-day week in government, which would save the discharge of 100,000 employes and would add 30,000 to the present list.

(j) The passage of the home loan discount bank legislation, which would protect home owners from foreclosure and would furnish millions of dollars of employment in home improvement without cost to the Treasury.

(k) Financial aid by means of loans from the Reconstruction Corporation to such states as, due to the long strain, are unable to continue to finance distress relief.

(l) The extension of the authority of the Reconstruction Corporation not only in a particular I called attention to last December—that is, loans on sound security to industry where they would sustain and expand employment—but also in view of the further contraction of credit to increase its authority to expand the issue of its own securities up to $3,000,000,000 for the purpose of organized aid to "income producing" works throughout the nation, both of public and private character.

"The vice in that segment of the proposals made by your society and others for further expansion of 'public works' is that they include public works of remote usefulness; they impose unbearable burdens upon the taxpayer; they unbalance the budget and demoralize government credit. A larger and far more effective relief to unemployment at this stage can be secured by increased aid to 'income-producing works.'

"By 'income-producing works' I mean such projects of states, counties and other subdivisions as water works, toll bridges, toll tunnels, docks and any other such activities which charge for their service and whose earning capacity provides a return upon the investment.

"I include in this class aid to established industry where it would sustain and increase employment, with the safeguard that loans for these purposes should be made on sound security and the proprietors of such industries should provide a portion of the capital. Non-productive 'public works,' in the sense of the term here used, include public buildings, highways, streets, river and harbor improvement, military and naval construction, etc., which bring no direct income and comparatively little relief to unemployment.

"These proposals of huge expansion of 'public works' have a vital relation to balancing the federal budget and to the stability of national credit. The financing of 'income-producing works' by the Reconstruction Corporation is an investment operation, requires no Congressional appropriation, does not unbalance the budget, is not a drain upon the Treasury, does not involve the direct issue of government bonds, does not involve added burdens upon the taxpayer, either now or in the future. It is an emergency operation which will liquidate itself with the return of the investor to the money markets.

"I have for many years advocated the speeding up of public works in times of depression as an aid to business and unemployment. That has been done upon a huge scale and is proceeding at as great a pace as fiscal stability will warrant. All branches of government—federal, state and municipal—have greatly expanded their 'public works' and have now reached a stage where they have anticipated the need for many such works for a long time to come. Therefore, the new projects which might be undertaken are of even more remote usefulness.

"Thus we have largely anticipated the future and have rendered further expansion beyond our present program of very remote usefulness and certainly not justified for some time to come, even were there no fiscal difficulties. They represent building of a community beyond its necessities. We cannot thus squander ourselves into prosperity.

"To sum up, it is generally agreed that the balancing of the federal budget and unimpaired national credit is indispensable to the restoration of confidence and to the very start of economic recovery. The administration and Congress have pledged themselves to this end. A 'public works program,' such as is suggested by your committee and by others, through the issuance of federal bonds creates at once an enormous further deficit.

"Such a program as these huge federal loans for 'public works' is a fearful price to pay in putting a few thousand men temporarily at work and dismissing many more thousands of others from their present employment.

"What you want and what I want is to restore normal employment. I am confident that if the program I have proposed to the Congress is expeditiously completed and we have the cooperation of the whole community, we will attain the objective for which we have been searching so long.

"Yours faithfully,

"HERBERT HOOVER."

Proposals Misunderstood, Says Civil Engineer's Public Works Committee

John P. Hogan, chairman of the American Society of Civil Engineers' committee on the public construction, in the absence of President Crocker, replies to President Hoover

OUTSTANDING differences between what the American Society of Civil Engineers proposed in its program for business revival through resumption of public construction and what President Hoover, in his letter to the president of the society, states that it proposed are pointed out in a statement by John P. Hogan, chairman of the society's committee on public works. The statement was made in the absence of Herbert S. Crocker, the president of the society. It follows in full.

"The committee is in complete accord with the President in the necessity of a quick, honest balancing of the federal budget and the provisions for the extension of credit relief. There are, however, in the President's discussion several statements attributed to the society which must have originated from some other source.

"Referring to the first paragraph of the President's letter, the American Society of Civil Engineers did not suggest 'that the depression can be broken by a large issue of federal government bonds to finance a new program of huge expansion of public works construction.' While the society in its program discussed various methods of financing, it declared its preference for the following method, as quoted from the memorandum presented to the President:

> The legislation necessary to effect the purpose proposed could be based upon that which has already found successful application in the Reconstruction Finance Corporation, i.e., the credit of the federal government could be extended to *reinforce* the securities of states, counties and municipalities that may be issued to finance necessary and useful public works. It is possible that this function might be assigned directly to the Reconstruction Finance Corporation or to some affiliated agency. If this be not feasible, an independent but analogous agency should be set up for this purpose.
>
> In operation, a federal credit corporation as here proposed would examine and pass on state, county and municipal projects for which money cannot now be raised. If these projects were found to be economically sound, properly planned and administered, it would purchase the necessary bonds or other approved obligations of the states or municipalities at reasonable interest rates, and would hold them until such time as they could be sold in the public market without loss The federal government thus would be eventually reimbursed, the cost of improvements assessed on the beneficiaries, and supervision would be provided to curb wasteful expenditure.

"The American Society of Civil Engineers did not advocate a huge increase in the *federal* program of public works but made the following statement in its memorandum.

> Federal public works alone, however expanded, cannot possibly meet the requirements of the situation. The major effort must be exerted through the state, county and municipal programs, which normally provide the bulk of our public works construction. But it is the municipalities and some of the states which have found great difficulty during recent months in raising sufficient funds at reasonable interest rates to finance their 1932 programs; and this is despite an urgent need for many such works, for which plans are already prepared and construction organizations in existence.

"While federal public works have been expanded during the current depression; state, county and municipal public works for which the normal expenditures during the past eight years were $2,500,000,000 will not exceed $800,000,000 for the current year, on account of the difficulty experienced by these latter subdivisions in obtaining money at reasonable rates of interest. The net effect of this decrease will be that over a million additional people will be thrown out of work during the present year on the work itself and in the industries furnishing materials.

"The committee is at a loss to know what is meant by the first sentence under topic one of the President's letter, which states that 'the proposals made by your society and others for further expansion of public work include public works of remote usefulness.' The society submitted no list of projects but urged 'the enactment of the necessary legislation to extend federal credit facilities to solvent states, counties and municipalities to enable them to carry out their programs of necessary and productive public works.' The society in its memorandum thus emphasized the point made by the President that any works undertaken by the states, counties, or municipalities should be of a productive or self-sustaining nature. Many types of public works not ordinarily self-sustaining from the point of view of revenue, can be made so by allocating a sufficient portion of the revenues created by such projects to the service charges and amortization of the securities issued against them. Thus, in the states of Missouri and North Carolina, a portion of the gasoline taxes has been definitely allocated to the service charges and amortization of the bonds issued against roads.

"It is the universal experience after a depression that the first revival in building is in construction of cheap housing either in individual dwellings or in low-priced apartments. The initiation of this work is universally recommended, both in the President's program and all of the various programs or bills which have been submitted to date. Such programs cannot go forward unless financing is provided for the necessary municipal improvements, such as water supply, sewerage and street paving. Normally this work is done through special assessments repaid by the property owner. Special assessments of this character should be included in any program of federal credit since it encourages private work several times the amount of municipal improvements and unless municipal work of this character is permitted to go forward, it will be very difficult to finance the housing projects.

"The committee reiterates the concluding statement of the memorandum of the American Society of Civil Engineers. 'Steps should be taken at once, therefore, to embody a program of public works construction in appropriate legislation, either as an amendment to existing law, as a new bill, or as a provision of some appropriate bill now under the consideration of Congress. There is urgent need for the trade stimulus that can be realized through a public works program, soundly planned and adequately safeguarded as here proposed. The guarantee of federal credit has been a healthy influence in restoring the security and stability of the financial structure; now is the opportunity to apply it to the actual stimulation of business recovery.'"

John P. Hogan, Chairman.

Sanitary Engineers, District Officials and Operators Hold Joint Meeting

Urge works needed be built now and deplore crippling of operating staffs—Dedicate Rockford (Ill) plant

More than 200 sanitary engineers, operators of sewage-works and sanitary district officials attended the joint meeting May 13 and 14 at Rockford, Ill., of the Central States Sewage Works Association and the Illinois Association of Sanitary Districts. Following the custom of the latter organization to meet where a plant has been newly completed and to dedicate that plant with fitting ceremony, the sewage-treatment works of the Sanitary District of Rockford were officially opened with talks by the state and district officials and engineers.

Feeling the pinch of tax economies, the meeting adopted a resolution similar to that put out by the American Water Works Association calling on officials to recognize that public health, community welfare and property are being jeopardized by the crippling of sewage-works where such are urgently needed. The lag in normal sewage-works construction amounts to many millions of dollars, and this construction could be supported by reasonable charges for the service rendered. Projects already planned could be started without delay and afford unemployment relief. Means for adequate financing at reasonable rates were urged. Drastic reduction in staffs was condemned as unwise.

S. A. Greeley, consulting engineer, briefly described the Rockford work at the dedicatory exercises. It consists of intercepting sewers skirting the Rock River and two tributaries carrying the sewage to the disposal site 3½ miles downstream from the center of the city and 1 mile south of the city limits. The disposal works comprise a pumping station, grit-removal tanks, primary settling tanks, sludge-digestion tanks, sludge-storage tanks and sludge-drying beds. The plant has been operated since Feb. 1, the settling tanks removing an average of 86 per cent of the settleable solids. The intercepters cost $2,200,000 and the plant $422,000.

Subjects on the program included the status of sewage disposal in New York by George W. Fuller, consulting engineer, and in Chicago by Langdon Pearse, sanitary engineer, Sanitary District of Chicago. Operating experience at Galesburg, Bloomington and Springfield, Ill., and Grand Rapids, Mich., and Dayton, Ohio, were detailed. Plain statements were made on aeration by H. E. Babbitt, professor of sanitary engineering, University of Illinois, who has been experimenting on various types. He called attention to the lower cost and simplicity of the mechanical means as compared with the diffuser types. Seven papers were presented in a symposium on sludge, covering chemical and physical properties, power in the gas, improved dewatering methods, fertilizer sales and incineration of grit and screenings.

Newly elected officers of the two organizations are as follows: president of the Illinois Association of Sanitary Districts, A. O. Lindstrum, president, Galesburg Sanitary District; and president of the Central States Sewage Works Association, C. K. Calvert, chemist, Indianapolis Sewage Commission. Gus H. Radebaugh, manager Champaign-Urbana (Ill.) Sanitary District, was reelected secretary-treasurer of both organizations. The next meeting of the Illinois association will be held at Galesburg.

◆

Fresno Irrigation District Clears Off Bonded Debt

With the ceremonial burning of $2,825,000 worth of Fresno Irrigation District cancelled bonds on May 12, the district has cleared off its entire bonded indebtedness and established a record as being the first district in California to accomplish complete repayment of funded debt. As a result it is estimated that the water duty for 1933 will be reduced from the present rate of about $2.50 per $100 of assessed valuation to $1.25.

The speakers on the occasion, including Lieut.-Gov. Merriam and other state officials, congratulated the farmers and the management on the success of their financial program and brought out the fact that since 1920, when the district was formed and the obligation assumed, repayments have been made during a period of agricultural stress. It was stated that when the bonds were voted it took 7 lb. of raisins, a major product of the district, to pay off one dollar of debt, but prices reached a level when it required 35 lb. of raisins to repay a similar amount of debt.

Work Started on Ship Terminal at Cartagena, Colombia

Late in April construction was started on a new steamship and barge terminal at Cartagena in Colombia to cost close to $3,000,000. The work will include the construction of two reinforced-concrete piers capable of docking large ocean vessels and equipped with modern facilities for transferring cargo to and from river barges. Warehouses are to be built on the piers for the storage and inspection of cargo, and railroad tracks both on the piers and along the bulkhead will give direct rail connection to the Bolivar Ry. and the Calamar Ry. Twenty-three acres of filled land will be created between the concrete bulkheads and the present shore line, providing sites for the new custom house, for a shore warehouse and for a possible future bonded warehouse, factory building, etc.

Contract for the construction of the terminal includes in all more than 2,500,000 cu.yd. of dredging. Part of this is to provide a 33-ft. depth of water alongside the pier and an improved river channel, but by far the greater part of the dredging is to be done in deepening and straightening "El Dique," a canal connecting Cartagena Bay with the Magdalena River at Calamar. Dredging will give a depth in the canal of 11½ ft. below mean low tide.

The piers will have a maximum length of 664 ft. and a width of 130 ft. The distance between the two piers will be 400 ft. Pier sheds will be of steel construction 80x570 ft. They will be provided with three semi-portal cranes of 3-ton capacity running the full length of one side of the pier. The marginal wharf will have a full-portal fixed crane of 15-ton capacity. There will also be a loading derrick of 20-ton capacity. The contract includes paving the streets serving the wharf and the streets connecting the wharf with existing streets in the city.

The capital necessary to undertake this development is to be furnished jointly by the government, the Andean National Corp. and the contractor, the Frederick Snare Corp., of New York. The contract is on the basis of an agreed lump sum price. F. J. Litter is chief engineer of the Frederick Snare Corp. and Alfonso Araujo is minister of public works of Colombia. The amount of the contract with the Frederick Snare Corp. is $2,850,000.

A new wharf, two piers for deep-draft ocean vessels and facilities for cargo transfer from steamship to barge or to rail are provided for Cartagena, Colombia, by a contract let late in April.

Indianapolis Public Works Board Condemns Low Wages

A resolution has been adopted by the board of public works of Indianapolis condemning the practice of contractors in that city of paying wages of 20c. an hour on street improvements. Such contractors are warned that wages will be taken into consideration when contracts are awarded. Union officials pointed out to the board that the wage reduction has not been reflected in the contractors' bids.

◆

Regulation of Private Motor Carriers in Kansas Upheld

The United States Supreme Court, on May 23, upheld the validity of the motor vehicle regulation act of Kansas. The Continental Baking Company, which operates delivery trucks, had filed a bill of complaint to restrain the enforcement of the act as unconstitutional. The court ruled that "private motor carriers of property" must obtain a license, pay a tax, and file a liability insurance policy in conformity with the Kansas statute. The court said, in part:

"The State of Kansas has constructed at great expense a system of improved highways. These highways have become the roadbeds of great transportation companies, which are actively and seriously competing with railroads which provide their own roadbeds; they are being used by concerns such as the plaintiffs for the daily delivery of their products to every hamlet and village in the state.

"The highways are being pounded to pieces by these great trucks which, combining weight with speed, are making the problem of maintenance well nigh insoluble. The Legislature but voiced the sentiment of the entire State in deciding that those who daily used the highways for commercial purposes should pay an additional tax. Moreover, these powerful and speedy trucks are the menace of the highways."

◆

Financial Problems Discussed at Irrigation Meeting

Refinancing problems proved one of the main themes at the convention of the California Irrigation Districts' Association, held in Fresno, May 12-13. Attended by representatives of many irrigation districts, engineers and state officials, the meeting was concerned principally with legal, financial and economic conditions as distinct from the more usual problems of operation and maintenance. The situation in districts now in default on bonds was discussed, in the light of the probability that other districts will default by the end of the year.

Opinions expressed indicated that the plan for state water development is considered inadvisable at the present time for legal, financial and political reasons. It was evident also that questions pertaining to the expansion or extension of irrigation would not even be considered, the discussions centering on the problem of maintaining present areas with proper financial reorganization.

Resolutions were passed at the meeting urging continued support of the Glenn-Smith bill, requesting state credit for existing irrigation districts in case the state water plan should include state financial credit for the Colorado River aqueduct project, and reemphasizing the association's support of the All-American Canal project. The association listened to plans for the refinancing of the Merced Irrigation District and discussed the relation between irrigationists and bondholders in matters of refunding.

One of the features of the convention was the burning of $2,800,000 worth of Fresno irrigation district bonds, the first time in California that an irrigation district has completed the repayment of its indebtedness in full. At the close of the convention the delegates were taken on a trip over the irrigated area of the Kings River, including territory of the Fresno, Consolidated and Alta districts.

C.&O. Railway Plans Work Totaling $10,500,000

Construction projects under way or contemplated by the Chesapeake & Ohio Ry. for 1932 aggregate a cost of about $10,528,000. They include the following works: four new single-track tunnels paralleling old tunnels, $6,007,500; second track and tunnel work on line revision, $1,156,000; new double-track tunnel and bridge on line revision, $1,148,000; enlarging and relining three tunnels, $1,365,000; overhead and undergrade crossings (including a railway grade separation), $640,000; sidings and yard tracks, $174,400; roundhouse extensions, $36,300. Maintenance-of-way projects include switch, signal and interlocking plants aggregating about $205,500.

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New York Engineering Societies Indorse Public-Works Program

The Metropolitan section of the American Society of Civil Engineers, at its annual meeting on May 18, voted to indorse the resolution favoring public works "to stimulate trade recovery and revive employment" which was adopted by the executive committee of the society on May 9 (see *ENR*, May 12, p. 732). The section also authorized the president to appoint a committee to cooperate with the society's committee charged with promoting the adoption of a public works program.

Details of the plan were given by Willard T. Chevalier, one of the drafters of the report adopted by the executive committee of the society. The economic aspects of the program were discussed by three men from outside of the profession, Stuart Chase, author of "Men and Machines"; Wilford I. King, professor of economics of New York University, and Virgil Jordan, economist, of the McGraw-Hill Co. Mr. Chase favored the public-works program as a means for obtaining a desirable amount of inflation. Inflation pushed to the bitter end, he said, would be disastrous, but a mild inflation would be of benefit. It would help business, labor and the home owner, and would be harmful only to the creditor class, which latter, he said, has been the only gainer by the deflation since 1929 and which now stands to lose by further deflation. Prof. King expressed the belief that the public-works program is worth trying in the present emergency, even though it has a possibility for being harmful rather than beneficial, by taking away employment elsewhere. This depends on the price of labor. He discussed labor as a commodity, and said that "when the price of labor comes down to the level of other commodities unemployment will automatically disappear." Therefore, he reasoned, if Congress establishes wage rates for public works at the 1929 level the program will fail.

Virgil Jordan strongly attacked those who have stampeded the government into senseless cutting down of government expenditures in a vain attempt to balance budgets. He characterized this as an effort to overthrow federal, state and local government by force—through the demand to abolish or cripple their function. He stated that the only force that is strong enough to overthrow the government of the United States is the refusal of the business communities and all who profit by the protection and privileges provided by government to be taxed for a portion of the collective needs of the community. The government, he said, is the only organization that can spend money without the requirement of making a profit and in times like this it is only the government that can introduce new purchasing power by spending our surplus on a "community equipment program."

John P. Hogan, chairman of the society's committee to promote public-works construction, then outlined the work of the committee to date. Subsequently a resolution was presented indorsing the action of the society in promoting the program. Opposition to passing the resolution without giving an opportunity for discussion to those opposed to the idea of such an expansion of public works was voiced by W. J. Barney, but his objection was not sustained and the resolution was adopted by a large majority.

At the close of the meeting officers for the ensuing year were elected. Malcolm Pirnie succeeds George L. Lucas as president of the section. Wm. J. Shea was reelected secretary.

Professional Engineers also act

The New York State Society of Professional Engineers, at its annual convention held in New York on May 21, added its approval to the public works program put forward by the American Society of Civil Engineers early in May. The society also took action urging the carrying forward of specific construction projects in the state and recommending to the political subdivisions of the state that they take whatever legislative action is necessary to make it possible for them to carry forward a program of public construction to relieve unemployment.

Favorable results from the society's campaign to stop the misuse of the term engineer throughout the state was reported to the society.

D. B. Steinman, consulting engineer, New York, was reelected president of the society.

Water Analysis Committee Appointed

To study water-analysis methods a standing committee on water analysis has just been formed by the American Society for Testing Materials, under the temporary chairmanship of Max Hecht, chief chemist, Duquesne Light Co., Pittsburgh. The development is an outgrowth of coöperation with the joint committee on boiler feed-water studies, with a view to extending it to industrial waters. Methods of analysis, terminology and interpretation of results of tests are the objectives of the committee's work.

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Capital and Contracts

Total value of engineering construction contracts for the United States for the week of May 26, 1932, also new capital issues, together with year-ago comparisons, follow:

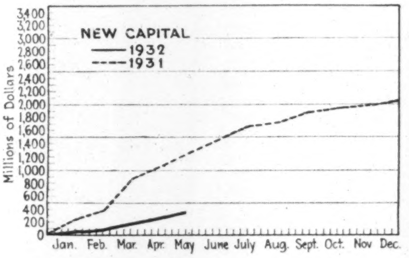
(Thousands of Dollars)

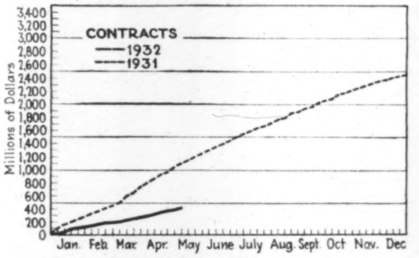
Construction:	Week of May 26, 1932	Average May, 1932	Week May, 1931
Federal government......	$10,459	$6,221	$2,585
State and municipal.....	7,694	12,744	27,924
Total public..........	$18,153	$18,966	$30,509
Total private..........	8,278	7,419	23,949
Weeks total.........	$26,431	$26,385	$54,458

New Productive Capital:	Week of May 21, 1932	Average May, 1932	Week May, 1931
Public.................	$26,000	$20,333	$28,000
Private................	......	......	26,200
Weeks total..........	$26,000	$20,333	$54,200

Cumulative Construction and Capital, Jan. 1 to May 26:

1932, construction.....................	$454,781
1931, construction.....................	1,198,671
Decrease, 62 per cent	
1932, capital..........................	$344,000
1931, capital..........................	1,295,000
Decrease, 73 per cent	





ENR Index Numbers

Cost		Volume	
May, 1932.....	**152.78**	**April, 1932.....**	**135**
April, 1932.....	153.12	March, 1932....	97
May, 1931......	189.33	April, 1931......	289
1931, average...	181.35	1931, average...	220
1930, average...	202.85	1930, average...	260
1913...........	100.00	1913...........	100

SOCIETY CALENDAR

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Atlantic City, June 20-24.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Yellowstone National Park, July 6-9.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, 40th annual meeting, Oregon State College, Corvallis, June 29-July 1.

AMERICAN FORESTRY ASSOCIATION will hold its 57th annual meeting jointly with the Maryland Forestry Association in Baltimore, Md., May 26-27. The keynote of the meeting will be water as a natural resource and the importance of watershed management in water conservation.

MONTCLAIR SOCIETY OF ENGINEERS, at its recent annual meeting, elected officers as follows: president, E. L. DeGolyer; vice-president, Harry Barker; secretary, Edgar K. Wilson; treasurer, Albert C. Vinal.

MINNEAPOLIS ENGINEERS CLUB at its annual meeting on May 16 elected officers as follows: president, M. D. Bell; vice-president, G. E. Loughland. The meeting voted to table a resolution indorsing the proposal that the federal government make loans to solvent states, municipalities and counties for public works to aid unemployment.

NEW YORK STATE BUILDERS BRANCH, Associated General Contractors of America, was formed recently at a meeting in Albany. Officers elected were: president, John P. Sewell, Albany; vice-presidents, Fred T. Delaney, Syracuse; Park Metzger, Buffalo; Thomas Cole, White Plains; secretary-treasurer, Waldo Griffith, Utica.

UTAH SOCIETY OF ENGINEERS will hold its annual meeting during the latter part of June in Salt Lake City. Nominees for office to be elected at the meeting are: president, C. C. Pratt; first vice-president, Fred H. Richardson; second vice-president, T. C. Adams; secretary, Ralf R. Woolley; treasurer, R. K. Brown.

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Personal Notes

George B. Sowers, formerly commissioner and chief engineer of the division of engineering and construction, department of public service, Cleveland, Ohio, announces the opening of an office as a consulting engineer in Cleveland.

Charles L. Hall, lieutenant colonel, Corps of Engineers, assistant professor of civil and military engineering at the United States Military Academy, has been assigned to duty as district engineer at Cincinnati, effective June 30. He will succeed Capt. J. D. Cleary.

Charles S. Bilyeu, formerly with Sanderson & Porter, of New York City, and R. W. Hunt Co., of Chicago, is now associated with the firm of Robinson & Steinman, consulting engineers, New York City.

Adolph J. Ackerman, hydraulic engineer, is now located in the Canal Zone at Madden Dam, having recently been appointed chief engineer in charge of engineering and office for the contractors, the W. E. Callahan Construction Co. and Peterson, Shirley & Gunther.

John Morrison, until recently chief engineer of the Woods Brothers Construction Co., of Lincoln, Neb., and W. F. Mason, formerly connected with the American Bridge Co., have formed a partnership under the name of Morrison & Mason Construction Co. and have opened an office in Kansas City, Mo. Associated with this firm is Charles M. Coff, formerly bridge engineer for the State of Nebraska and recently construction engineer with Woods Brothers Construction Co.

Blake R. Van Leer has been appointed dean of engineering at Florida University and will assume his new duties on Sept. 1. Mr. Van Leer was formerly associate professor of mechanical engineering at the University of California, specializing in hydraulics, and later was assistant secretary of American Engineering Council.

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Obituary

Cyrus Avery Whipple, of Seattle, Wash., a consulting engineer specializing in hydraulic properties appraisals, died recently at the age of 56. Mr. Whipple was born in Iowa and was graduated from the University of Washington.

George A. King, waterworks superintendent of Taunton, Mass., since 1903, died recently at the age of 76 years after a brief illness. Mr. King was a graduate of Lawrence scientific school, now a part of Harvard University. He was city engineer of Taunton from 1898 to 1902. Mr. King was active in the affairs of the New England Water Works Association, of which he was a past-president.

Everett T. Cain, assistant bridge engineer of the Canadian National Railways for the Atlantic region, died suddenly at his home in Moncton, N. B., on May 12. Mr. Cain, after his graduation in engineering from the University of Toronto in 1913, became a member of the engineering staff of the Dominion Bridge Co., at Montreal, later going to the C. P. R.

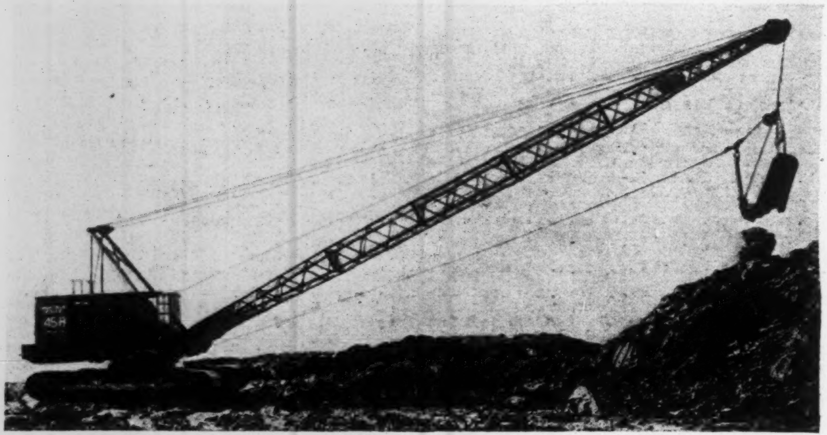
Edwin H. Messiter, formerly chief of party on surveys for the Rapid Transit Commission, New York City, and more recently engaged in the design of electrical weighing devices, died May 24 at the Long Island College Hospital. Mr. Messiter graduated from Columbia as a civil engineer in 1894.

Gilbert E. Ryder, vice-president of the Superheater Co., New York and Chicago, died on May 17 at his home in Larchmont, N. Y., from a sudden heart attack. Mr. Ryder was well known in railroad circles for his articles and speeches on fuel conservation and increase in power of locomotives through the use of superheated steam. He studied engineering at the University of Wisconsin and the University of Illinois, beginning his railroad experience with an apprenticeship on the Chicago, Milwaukee & St. Paul Ry. At one time he served the city of Chicago as deputy smoke inspector in charge of locomotives and following this became associate editor of the *Railway Review* (recently absorbed by *Railway Age*). In 1911 he joined the Superheater Co. as a service engineer and was elected vice-president in charge of sales and service in 1921.

Construction Equipment and Materials

Dragline Mounted on Long Crawler Treads

Bucyrus-Erie Co., South Milwaukee, Wis., has introduced a new dragline on a mounting especially designed for dragline work. The machine, known as the 45-B, is mounted on long tapered crawlers, which enables it to work on and cross soft ground easily and without nosing in. The treads are 19½ ft. long. The machine is equipped with a 155-hp. six-cylinder engine. It can handle a 2- or 2¼-yd. bucket on a 50-ft. boom or a 1¼- to 1½-yd. bucket on a 65-ft. boom. Booms are available up to 80 ft. in length. The machine steers like a tractor through clutches controlled by a lever at the operator's side, and makes sharp or gradual turns with the cab in any position.



New Bucyrus-Erie dragline.

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Aluminum Wheelbarrow

A lightweight wheelbarrow constructed entirely of aluminum with the exception of the axle and weighing but 37 lb. is a product of the Cleveland Wheelbarrow & Mfg. Co., Bedford, Ohio. The wheelbarrow has a sheet metal tray blanked out of 14-gage aluminum sheet, formed and beaded in the usual manner. The handles are tubing and the braces are aluminum channel sections. Heavy plate is used for the wheel disk, while the tire is fabricated from ¼-in. bar. The wheel is equipped with roller bearings. It has a capacity of 3 cu.ft. of wet concrete, or 4 to 5 cu.ft. of sand. High strength aluminum alloys are used throughout.

Aluminum wheelbarrow.

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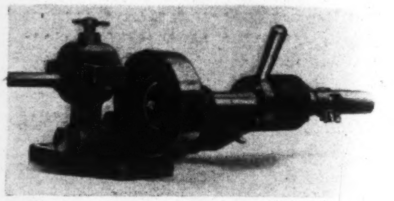
New Equipment in Brief

Pulsometer Steam Pumps—The Pulsometer Steam Pump Co., Irvington, N. J., announces a new series of Type R Pulsometer pumps. The new series, available in suction line sizes from 1½ to 8 in., has redesigned steam ports and valves, requiring less steam than the former models. The pumps will handle semi-solids as well as liquids, and will pass stones and sticks, marsh grass and sludges. They need no foundations, but can be hung in place from any suitable support.

Shoulder-Finishing Machine — Moritz-Bennet Corp., Effingham, Ill., announces several improvements on the Moritz shoulder-finishing machine. The feature of the pull drawbar being located outside the frame has been retained in making the frame heavier and more rigid. An important new feature is a moldboard couple bar extending from the inner rear end of the blade to the frame, which reverses the side thrust action when the blade is under heavy load. Other improvements are: new sectional boom that accommodates various length blades for finishing shoulders up to 11 ft. wide with all four wheels riding on the pavement; positive screw-type adjustment for sloper blade; and an auxiliary blade for cleaning pavement. Literature describing the improved machine is available from the manufacturer.

Drill Steel Shank Grinder

Ingersoll-Rand Co., 11 Broadway, New York, announces the new shank grinder, a tool for facing the striking ends of drill steel shanks, rock drill and paving breaker pistons, and anvil blocks. The machine consists of a "Multi-Vane" air grinder mounted in a frame so as to allow the grinding wheel to be passed back and forth by means of a handle. The steel or piston is held in a self-centering block clamp incorporated in the frame. A countersinking bit is located in the center of the grinding wheel for removing the burr from the hole in the hollow drill steel. The complete machine can be bolted securely to the top of a work bench or other suitable location.



Ingersoll-Rand drill steel shank grinder.

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New Publications

Wear and Lubricant Tester—A 12-p. booklet issued by the Timken Roller Bearing Co., Canton, Ohio, describes the new Timken wear and lubricant tester. This is a comparatively simple device for determining the load-carrying capacity of lubricants, for measuring amount of friction and for determining the wear characteristics of all kinds of material.

Wire Rope Economy—The American Cable Co., Inc., 230 Park Ave., New York, N. Y., has issued an illustrated booklet entitled "The Cardinal Reasons Why You Save Money With Tru-Lay Preformed Wire Rope.".

Concrete and Bituminous Pavement Finishers—The Lakewood Engineering Co., Columbus, Ohio, has issued two bulletins covering application of the Lakewood finishing machine to concrete highways and streets and to bituminous pavement. Bulletin No. 47-F describes in full the Lakewood finishing machine and its application to concrete roads and pavements. This bulletin also describes the Lakewood road and curb forms, the new Lakewood form tamper, batch boxes and cars, aluminum straight-edges, hand belts, float bridges, subgraders, and also the Jaeger heavy-duty road pump. The application of the Lakewood finishing machine to bituminous pavements is described in bulletin 47-E.

New Type Circuit Breaker—The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., announces two illustrated circulars on its new line of "De-ion" circuit breakers. These breakers use a new method of arc extinction, eliminating all fuses in panelboards, distribution switchboards within the breaker's capacity and industrial applications where fused safety switches are now used. Circular 1939 contains a general description of the new breakers, and circular 1937 gives details of the 225-amp. breaker.

Reduction Gears—The Murray Iron Works Co., Burlington, Iowa, has published a new bulletin, No. T-111, describing its lines of high-speed herringbone reduction gears.

Concrete Pipe—The American Concrete & Steel Pipe Co., P.O. Box 1428, Arcade Station, Los Angeles, Calif., has issued a 24-p. bulletin containing information concerning Hume centrifugally spun reinforced-concrete pipe, Lock-Joint steel cylinder reinforced-concrete pipe, and Hume concrete-protected steel pipe. For the most part, the information is given in answers to a set of hypothetical questions concerning the characteristics of the various types of pipe.